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Petroleum
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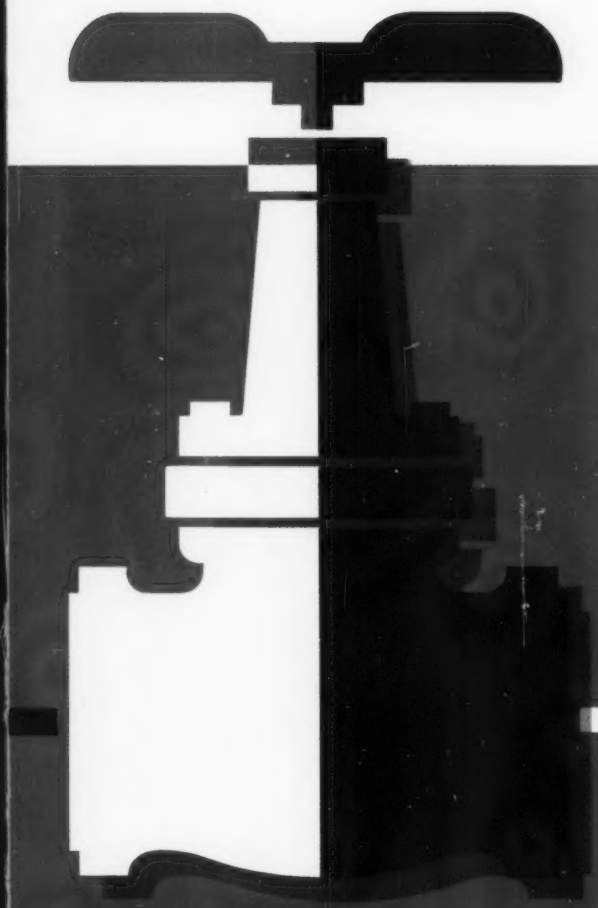

valves

How to select valves for the right job at the lowest cost

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OCTOBER 1961

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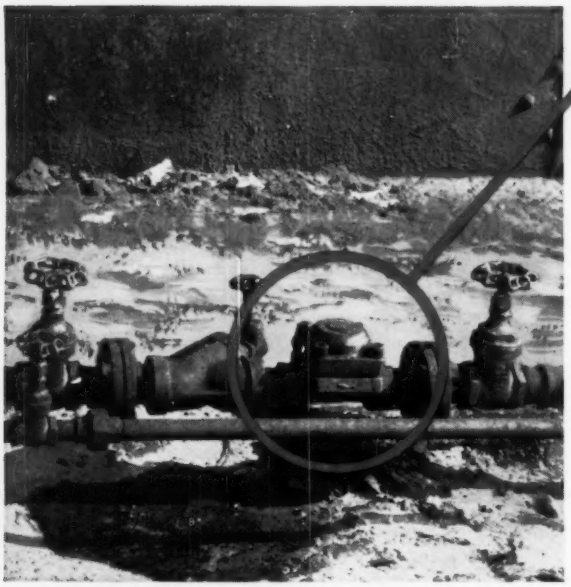
Latest Construction Boxscore 241

YARWAY Y news briefs

from **Yarnall-Waring Company,** *Philadelphia 18, Pa.*

BRANCH OFFICES IN 19 UNITED STATES CITIES • SALES REPRESENTATIVES THROUGHOUT THE WORLD • STEAM TRAPS STOCKED AND SOLD BY 270 LOCAL INDUSTRIAL DISTRIBUTORS



THIS STEAM TRAP WILL DISCHARGE 25,500 LBS. OF CONDENSATE PER HOUR

This is a typical installation of a Yarway Series 40 Impulse Steam Trap—a trap designed specifically to gobble up extra heavy condensate loads.

The trap is a No. 48, 2½" size, and is installed on a suction heater connected with an 86,000 barrel tank containing fuel oil at a storage terminal. The operating pressure is 13 psi. At this pressure the trap has a capacity of 25,500 lbs. continuous discharge of condensate per hour.

At operating pressure of 100 psi, the trap's capacity is 62,000 lbs. per hour.

CAPACITY—PLUS

Capacity isn't the whole story on Yarway Series 40 Steam Traps. Like all Yarway Impulse Traps, they offer advantages like quick heat-up, even temperatures, small size, good for all pressures, non-freezing.

Series 40 traps also feature high temperature discharge characteristics, excellent low pressure operation, no airbinding, operation against back pressures up to 40%, and stainless steel construction.

You can get Yarway's latest steam trap Bulletin T-1743, or arrange for a free 60-day trial of a Yarway Impulse Trap, by writing to Yarnall-Waring Company or contacting your local Industrial Distributor.

Yarway ½" No. 40 Impulse Steam Trap (shown actual size). Also available in ¾", 1½", 2" and 2½" sizes.

YARWAY OFFERS IMPULSE STEAM TRAPS FOR THESE SPECIFIC OPERATING CONDITIONS

AVERAGE CONDENSATE LOADS	EXTRA HEAVY CONDENSATE LOADS	LIGHT CONDENSATE LOADS
Series 60	Series 40	No. 30

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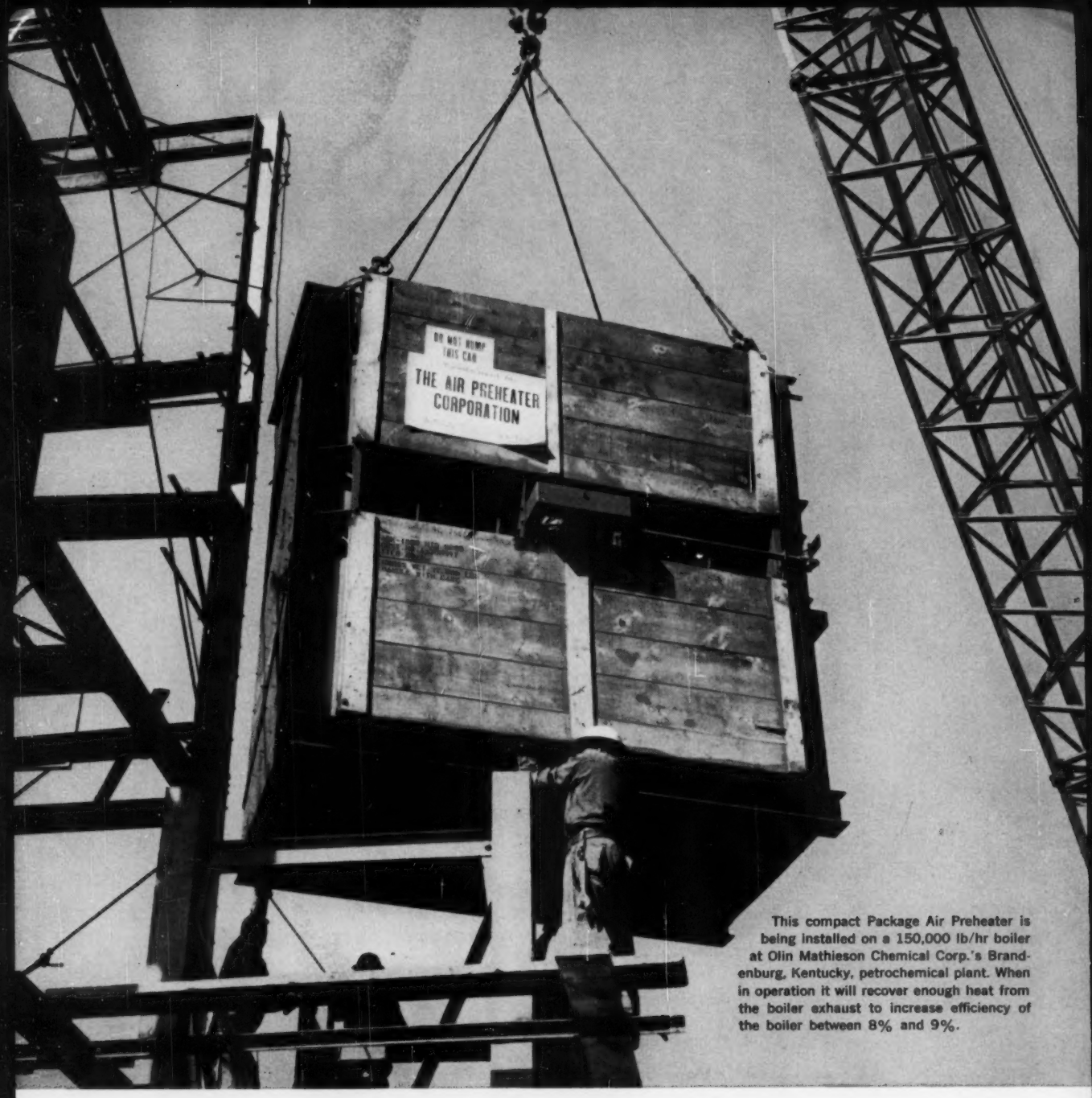
NOW . . .

For a "Quick Look" at this issue, turn the page



This compact Package Air Preheater is being installed on a 150,000 lb/hr boiler at Olin Mathieson Chemical Corp.'s Brandenburg, Kentucky, petrochemical plant. When in operation it will recover enough heat from the boiler exhaust to increase efficiency of the boiler between 8% and 9%.

OLIN MATHIESON RECOVERS 360°F FROM BOILER EXHAUST WITH 11½′ x 11′ x 8′ PREASSEMBLED LJUNGSTROM® PACKAGE AIR PREHEATER

Olin Mathieson specified a Ljungstrom Package Air Preheater because it saves space as well as fuel. Mathieson's Ljungstrom occupies only about 1000 cubic feet, but cuts boiler exhaust temperature from 680°F to 320°F — puts 360° of heat back to work in the boiler.

The compact preassembled Package Air Preheater is ready to run when it's delivered—just connect to the power line and ducts, and it's on-stream. You make big savings on installation because there's no on-the-spot erection.

You can use a Ljungstrom Package Air Preheater on boilers from 25,000 to 250,000 pounds of steam per hour. For more information, write today for your free copy of a 14-page booklet.

THE AIR PREHEATER CORPORATION

60 East 42nd Street, New York 17, N. Y.

A Quick Look at This Issue

☐ **Valves for Today's Hydrocarbon Processing Plants . . .** Engineers are taking a longer look at valves in the hydrocarbon processing industry today because they represent a sizeable amount spent for process equipment in both capital expenditures and through the maintenance budget. New ideas are being considered, some for the first time, by refiners. They have been very reluctant to use valves with plastic seats or ductile iron bodies because of fire hazards. Their neighbors in petrochemical plants have been using these materials with good success, and many old timers are being convinced. For a look at valves used in the industry today, with emphasis on how to select the right valve for performance and economy, turn to **Page 121.**

☐ **Make Olefins This New Way . . .** Lurgi-Ruhrgas' sand cracker produces olefins from a wide range of stock. To see how flexible the process is when propylene : ethylene ratios range from 0.3 to 0.9, turn to **Page 137.**

☐ **Check Ways to Measure Catalyst Size . . .** Here is a critical examination of ways to measure true particle size distribution. To discover why different methods give different results and why one method is recommended as better than the others, see **Page 139.**

☐ **Thermo Data for Petrochemicals (Part 32) . . .** Here are additional thermo data concerning symmetrical dithia alkanes. To supplement your thermo data notebook, be sure to clip this one, starting on **Page 145.**

☐ **How Conoco Justified Vapor Recovery . . .** Besides vapor conservation, Conoco has realized $29,440 gross monthly income from five lease vapor recovery systems recently installed in the Denver-Jules Basin. For details about equipment selected, economics and operating experience, see **Page 148.**

☐ **Microscope Speeds Diagnosis of Refinery Corrosion . . .** A number of case histories and 36 photographs are used to show how a metallographic diagnosis helps to clarify and identify equipment failures caused by corrosion. Check your own corrosion problems against these examples to be sure you are prescribing the right cure. **See Page 151.**

☐ **Ethylene Oxide Goes for Two Billion . . .** While uphill all the way, ethylene oxide can make its goal with process improvements and aggressive development of new markets. For complete details, turn to **Page 159.**

☐ **Equipment Cost Data File (Part 7) . . .** For a rundown on cost data for horizontal axial flow, centrifugal pumps and multi-stage, horizontally split centrifugal pumps, turn to **Page 167.**

☐ **Computer Sets Tower for Best Run . . .** Here's a case study of a search-type controller. It seeks the most profitable operation of a deisobutanizer by making a series of changes to the tower's operating variables. After the best operation is found, the control system continues to explore changes to handle any variations while the tower is running. For the full story, see **Page 169.**

☐ **Figure Separations This New Way (Part 6) . . .** This part refines the Θ-method of convergencies. The method is a powerful tool with a digital computer. For ways to minimize round-off errors and other developments, turn to **Page 175.**

☐ **Catalog Helps Cut Warehouse Stocks . . .** Phillips found that 42 pump shafts were carried in one of their warehouse stores where only six were required to meet all operating problems. An all-inclusive, company-wide materials catalog has eliminated this costly storage. For details on what the Phillips' study showed, turn to **Page 184.**

☐ **New Methods Give High Temperatures . . .** Here is a review of current activity in the fascinating field of ultra-high temperatures using such tools as shock tubes, magnetohydrodynamics, plasma jets and other electromagnetic principles. For details of their effects on chemical reactions, turn to **Page 185.**

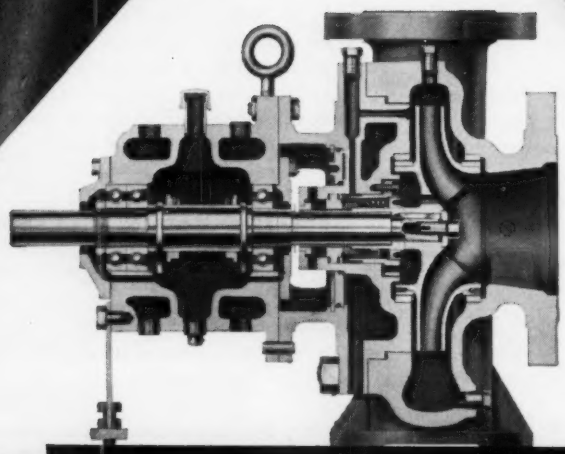
☐ **Management Development . . . Past, Present, Future (Part 1) . . .** Management has come a long way since the era of the "tycoon" and "sweat shop." Increasing industrial complexity has paved the road to the so-called "professional" manager. This first part of a three-part series sets the stage for what constitutes today's management training, and what it will be like tomorrow. See **Page 193.**

☐ **Judging People by Psychology (Part 1) . . .** How often we have heard the admonition—"know thyself." This article shows the soundess of this advice as a guide to good business and human relations. For the basic principles of human behavior that will help you understand yourself—and others—better, turn to **Page 199.**

☐ **How Conoco Teaches Leadership Fast . . .** Here's a fascinating insight into leadership behavior, and how employes react to various types of leaders. You'll learn how a clever, three-hour training session teaches Conoco supervisors the dynamics of effective leadership—in a way they'll never forget. Just turn to **Page 205.**

Why buy more pump than you need for

HOT LIQUIDS ?



You take two big bites out of costs when you buy a Goulds Pump that *fits* your hot pumping service. You don't pay for more pump than you use—yet you have expensive pump features that keep maintenance costs down.

The Goulds Model 3775 handles liquids *as hot as 750°F*—and pressures up to 600 psi. Gives you all these features:

1. Cooled seal. Hot pumpage never touches the mechanical seal—because the seal is isolated in its chamber and surrounded by cool, dead-ended liquid. Coolant circulates through jacket to keep seal face to 250°, even when pumpage reaches 750°. A simple adjustment lets you change to external flush or heat exchanger cooling.

2. Cooled feet. Alignment stays true regardless of temperature variations because of centerline mounting and tapped inlet and outlet connections that permit circulation of cooling liquid.

3. Cooled bearings. Water-cooled housings maintain constant bearing temperature for longer life.

BACK PULL-OUT FOR EASY UPKEEP. A millwright alone can remove rotating parts without disturbing pipe connections or driver.

You get maximum economy in spare parts inventory, since all twelve sizes are built on the same bearing frame—one size bearings, shaft and seal for all pumps.

The husky Model 3775 is built to API specs, with a vertically split casing. Capacities go to 1200 gpm and heads to 500 feet.

Bulletin 724-1 gives you a more complete look at how Model 3775 can help you cut costs on hot pumping services. It contains specifications, construction details, pressure-temperature chart, and other helpful information. Write to Goulds Pumps, Inc., Dept. PR-10, Seneca Falls, N. Y.

GOULDS PUMPS

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HYDROCARBON PROCESSING & PETROLEUM REFINER and The REFINERY CATALOG for the hydrocarbon processing industry.

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PIPE LINE INDUSTRY and The PIPE LINE CATALOG for the oil and gas pipe line industry.

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Double-Barreled

HP-PR HAS A DOUBLE-BARRELED TREAT for you next month. Being it's November, one of these barrels is our Fifth Petrochemical Handbook Issue. You can bet it will be better than its immediate predecessor because in it you will find for the first time anywhere, many brand new processes. This Handbook Issue packs quite a load with all "standard" processes, which continue to carry petrochemicals along to new heights, plus the aforementioned new ones.

And that other barrel is the start of a series on hydrocarbon oxidation: "Combine Oxygen and Hydrocarbons for Profit" by Marshall Sittig. This you'll look for and clip each month because it's a most extensive study of an important petrochemical process. Sittig will begin with an introduction to the chemical and economic fundamentals of hydrocarbon oxidation, will then discuss the making and handling of oxygen and as the series continues present such topics as paraffin oxidation, autothermic cracking aromatic oxidation and finally coal and coke oxidation. A look into the future also will be included.

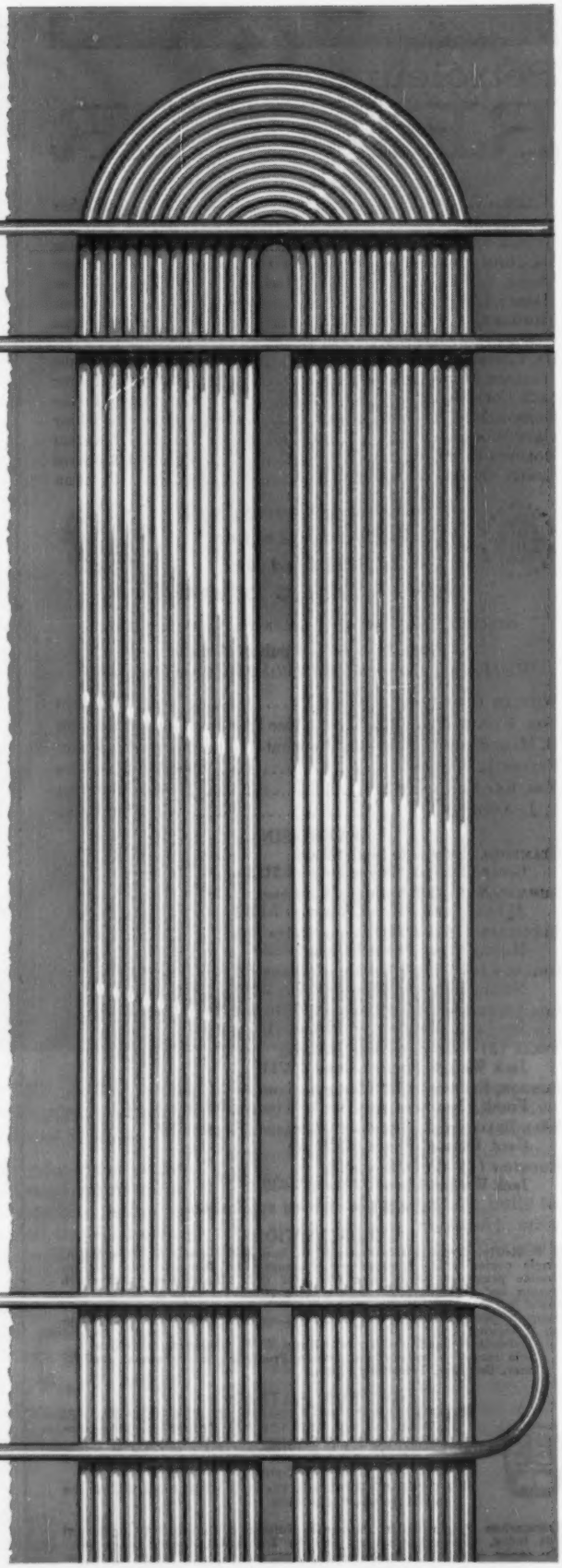
Further Plug

YOU GET a pretty good idea from the above that HP-PR editors are right proud of our Handbook issues (Process in September of "even" years and Petrochemicals in November of "odd" years). And well we might be, because over the years these have gained such stature as to become the standard reference works of their two HPI fields. The upcoming Handbook Issue covering petrochemicals, which will present flowcharts of 110 processes, we can assure you, will be kept on thousands of industry desks for the next two-year period. Such use increases the book's value and makes extra copies hard to come by. So unless you are adept at reaching through barbwire entanglements, where the smart co-worker likely will be keeping his copy for safety's sake, you'd better arrange to get on the subscription list. If you will, right now, fill out the postcard and mail it promptly, your subscription will commence with this happy-to-have number.

Readers Far & Wide

NOW AND THEN when the talk gets around to it, we tell our friends about HP-PR's foreign subscription list. And, apparently, it never fails to astonish them a bit. One of the choice morsels has been that Japan, of all countries outside the U.S.A., has the largest number of subscribers to this magazine. So we'll set down here just a few June 30 figures with the thought that you too will be interested. Twenty hundred seventy-five is the paid list going to Japan these days. Canada ranks second with 1308, but Italy is fast moving up with 1152. Others of interest: England 725, Germany 515, France 402, Netherlands 329, Brazil 266 and faraway Australia 250.

NEW FEEDWATER HEATER TUBE



provides high strength ... at lower cost

ANACONDA CUPRO NICKEL, 30%-707 provides important money-saving advantages over generally used feedwater heater tube alloys. Approved for condenser and heat exchanger use by the ASME Boiler & Pressure Vessel Code Committee, it offers highly desirable properties for power plant feedwater heaters . . . at lower initial cost.

A point-by-point comparison of mechanical properties is detailed in our Publication B-45.

Of course, this high-strength copper-nickel-iron tube alloy is only one of the many Anaconda alloys available for various types of heat exchangers. These include arsenical admiralty, red brass, 10% and 30% cupro nickels, phosphorized coppers, and Anaconda's own Ambraloys, Ambronze, and Everdur®.

For the complete story, ask your nearest Anaconda technical representative, or send for our 44-page Publication B-2 and Cupro Nickel, 30%-707 Publication B-45. Address: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 61-920

CUPRO NICKEL, 30%-707
Weldable
High Strength
Corrosion Resistant
Stress-corrosion Resistant

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AMERICAN BRASS COMPANY

From the editors...

Quick Look at HPI

AUTO ENGINEERING TRENDS over next 10 years will feature economy, says Chrysler Corp. executive. The route: Refinements in internal combustion engine, reduced car weights, lower numerical axle ratios. The refiner's problem: Having the right gasoline octane levels.

SCHOOL DAYS, SCHOOL DAYS, dear 'ol golden rule days could be the theme of latest Engineering Manpower Commission survey. It reveals that 23.7% of chemical engineering grads are staying in school for graduate studies. Also, U.S. Office of Education says there will be 1,500 candidates for Ph.D. degrees in engineering this year, while physical sciences will turn out 2,400. Meanwhile, Engineers Joint Council reports Soviet Union is yearly graduating 117,000 engineers, compared with 38,000 for U.S.

DISMISSAL OF PATENT SUIT in news as Du Pont reaches agreement with Phillips Petroleum concerning alleged patent infringements of high-density linear polyethylene process. Settlement involves exchange of patent rights—no cash. Suit was started in 1958 by Du Pont, charging Phillips with making dupe product Du Pont says it had nailed down in 1957.

OIL INDUSTRY CLEAN AS DRIVEN SNOW in government investigation of identical bidding for government contracts. In Joint Economics Committee report, no oil companies were named. Petrochemicals came out lily white too in study of unethical bidding practices. In report's section on chemical industry, one of most heavily involved in investigation, no petrochemical companies were mentioned.

OHIO OIL BRACES FOR LAWSUIT by Cepsa, Spain's privately owned refining company. At issue: Whether or not government should grant refining rights to Ohio. Cepsa charges "procedural errors and irregularities of concept by Ohio"—but key question is competitive advantage Ohio would have because of Spanish government's controlling interest. Ohio and government plan to build two separate plants in northern Spain.

COMMERCE OIL'S LONG-TIME FIGHT to build $55-million refinery at Jamestown, R.I., over objections of Rhode Island Protective Association, still goes on. Latest development: U.S. District Judge upheld right of 17 members of RIPA to sue Commerce for $100,000 each over alleged malicious use of legal process. Ruling came on one of three Commerce motions to dismiss charges. Meanwhile, Shell Oil has its own problems at New Castle County, Del., where citizen's group seeks to block construction of $80-million refinery there. Their goal: Injunction against Shell, and action to rezone 2,625 acres to keep plant out. However, group has thus far been unable to raise $500,000 bond asked by court before injunction can be issued.

ASPHALT RESEARCH IN LIMELIGHT as Asphalt Institute reports refiners will spend more than $4.5 million on asphalt products research in 1961. In study of 49 U.S. and Canadian member companies, Institute found that 12% more money has been allocated for asphalt research in 1961 than last year.

ON CONSTRUCTION SCENE, new 85,000-bpd crude distillation unit at DX Sunray's

Tulsa refinery is one of first in nation to use computer control system. It replaces five older units with combined capacity of 75,000 bpd. For panoramic view of world-wide construction activity in HPI, see pages 227 through 269.

NEW COMPANIES AND MERGERS in news as Du Pont sets up firm with Establissments Kuhlmann, Paris, to make isocyanates for rigid and flexible urethane foams in European Common Market. New firm, Dekachimie, will be owned on 50-50 basis . . . Enjay Chemical and J. P. Stevens & Co. buy National Plastics Products to form jointly owned company aimed at commercial development of polypropylene Fibers. Company will retain present name, adding its fiber experience to Humble's background in synthetic polymer chemistry . . . Cosden Petroleum sets up new subsidiary, Cosden Petrochemical, New York. Company says petrochemicals now account for one forth of net income.

Monsanto centralizes European operations at Geneva, Switzerland. All of company's overseas work will now be handled through Monsanto Overseas S.A. (MOSA) . . . Catalin Corp. of America buys out Lebec Chemical, Paramount, Calif., which specializes in synthetic resins . . . Union Carbide sets up integrated R & E Department at South Charleston, W. Va., Technical Center . . . Air Products & Chemicals purchases Delta Oxygen, Memphis, Tenn.

Atlantic Refining acquires majority interest in J. P. Frank Chemical & Plastic, New York . . . Merger of Murphy Corp. with Ingram Oil & Refining gets final approval . . . Standard of California and Standard of Kentucky complete merger . . . Jacobs Engineering sets up Jacobs Constructors for world-wide building and maintenance of processing plants . . . Ohio Oil forms new Chemical Product Development Division at Denver to give more emphasis to petrochemicals. Company is also organizing comprehensive division for overseas development.

QUICK LOOK AROUND THE WORLD finds India's Sindri Fertilizer Factory collecting damages (about $500,000 so far) from Montecatini because of latter company's "failure to meet design-rated capacities." Plant was supposed to produce 25,000 tons of urea a year, but last year's optimum capacity was about 11,000 tons . . . Government orders Hooker Chemical to divest itself of phenolic molding materials bought from Monsanto in 1958, because of "tendency to create monopoly" . . . Foreign investment in plants and equipment by U.S. chemical companies on way up, says Commerce Department. The breakdown: $237 million in 1960; $288 million in 1961; $301 million planned for 1962.

"Sliding-scale" import provision lawsuit, filed by Standard of New Jersey, goes on trial next month . . . API recommends oil changes at least every 2,000 miles for new cars. Extensive tests showed that piston-ring wear, dirt, sludge and varnish become major problems when intervals are extended from 1,000 to 2,500 miles . . . Senate gives final OK to national fuels policy study. It will run through January 31, 1962 and cost $25,000, at which time Senate will consider further study and appropriations if needed.

PANNING THE PROCESS scene you'll see Union Oil's Clathration process being used by Cosden in 5-million-pound-per-year metaxylene plant . . . U.S. Rubber Reclaiming Co. up with acid solvent process for recovering nylon from scrap tires . . . For these and other latest developments in HPI technology, see "What's Happening," starting on page 39.

A Yuba Heat Transfer Corporation Petro-Chem cylindrical heater being lined with B&W Insulating Firebrick.

Why Should This Oil Heater Lining Last 21 Years—or More?

THE ANSWER: B&W INSULATING FIREBRICK

Since 1940 B&W Insulating Firebrick have been used to line over a thousand oil heaters of this type. B&W K-1620, K-20, or K-23 IFB are being used successfully for direct exposure in this service, depending on operating conditions. Recent inspection of many units has shown that the B&W IFB linings were still in excellent condition. That's why Yuba Heat Transfer Corporation looks forward to a long and profitable service life from each new B&W IFB lining.

B&W Insulating Firebrick reduce over-all cost in chemical and petroleum process furnaces because they offer:

Long Life — B&W Insulating Firebrick are long lasting because of the exceptional refractory nature of their base ingredients and the high processing temperatures to which they are subjected during manufacturing.

High Hot Load Strength — B&W IFB provide maximum load-bearing capacity under operating temperatures. Many oil heaters have been built with walls 80 feet high with no intermediate supports.

Low Heat Flow — The porous structure of cost-cutting B&W IFB gives excellent insulating properties and this means extremely low heat flow.

Bulletin R-38 contains complete data on lightweight B&W Insulating Firebrick. Write for your copy to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, New York.

R675

B&W THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

Gas purity goes up, costs go down with Solvay Potassium Carbonate!

The Hot Carbonate Process, using Solvay® Potassium Carbonate, is the economical way to scrub carbon dioxide from process gasses, and carbon dioxide, carbonyl sulfide, and hydrogen sulfide from natural gas. The process yields a gas conforming to natural gas pipeline specifications.

The Hot Carbonate Process is efficient—it reduces steam requirements and the need for costly heat exchangers, because absorption and regeneration are carried out at essentially the same temperature. Wherever conditions of fairly high concentration and partial pressure exist, this system should be considered as the most economical means of gas scrubbing!

A NEW, FREE BOOKLET tells you all about "The Hot Potassium Carbonate Process for Acid Gas Absorption." Write us today on your letterhead for your copy. Ask for Technical Service Report No. 6.61.

Allied Chemical

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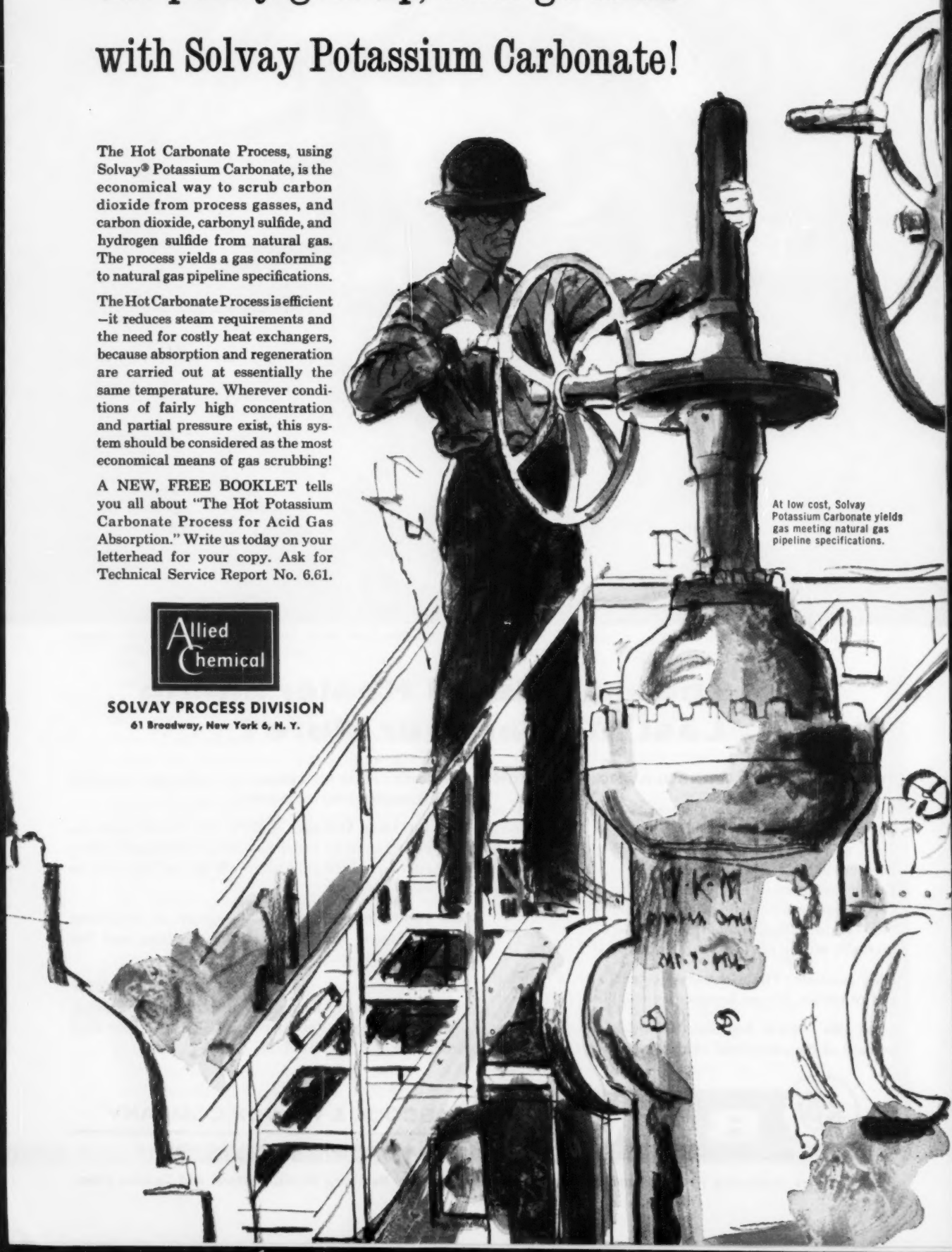
61 Broadway, New York 6, N. Y.



At low cost, Solvay Potassium Carbonate yields gas meeting natural gas pipeline specifications.

On Keeping Engineers Informed

DOES YOUR COMPANY keep engineers fully informed on company policy and operations?

In a survey conducted by the National Society of Professional Engineers it was disclosed that only 49 percent of three to six-year employes of 11 large corporations are satisfied with present communications with their managements.

This percentage represents a big problem that many engineers are complaining about: "All our communications are one-way. We send reports, plans, etc., to the top brass, but nothing comes down. And when we do hear anything from top management, it's never first-hand, but always information transmitted through word of mouth from one supervisor to another and so on."

Many may say this is a problem for the Employe Relations Division to solve. Nevertheless, every employe, whether he be in employe relations, research and development or maintenance, must know what his big bosses are planning or doing. In other words, the core of the problem lies with top management in designating the dispersal of information.

Top Management. Before we go any further, let's define what top management is. As we commonly refer to it, management consists of the plant manager, plant supervisors and possibly some vice presidents, that is, those concerned with particular departments.

We can call the communicating of information from the top of the ladder on down to middle management and engineers "downward communications." These are very important to the moral of the individual because if he does not understand a subject that concerns him, nor the reason "why," he is bound to be dissatisfied.

Specific causes have shown that communication through multiple layers of supervision frequently results in garbled or distorted facts, and is very time consuming.

Solutions to improve downward communications may be group information meetings, confidential newsletters, company publications and bulletin boards. Probably the best method is the newsletter. It is helpful in many instances, if issued periodically, in explaining the why and including all information that those concerned may need as well as want to know. And if confidence is a management concern, here again the newsletter would be the best route.

Du Pont has originated some ideas in connection with group information meetings. It set up these techniques to aid engineers in their communications with employers: (1) annual meeting discussion groups, (2) periodic technical reviews where a few engineers briefly outline their duties and gain an understanding of company policies.

The part that employe publications or house organs play is also an important element in HPI's expanding program of communications. They may be either newspapers or magazines, but management often does not make full use of their vast potentialities.

Silent Treatment. Bad communications between employer and employe may be viewed as the "silent treatment." As seen by David Summers, president of a Pittsburgh public relations firm, "Management's attitude toward employe publications is a paradox. What well-run company would make an investment without expecting a fair return? Yet how many companies spend thousands of dollars every year for employe publications and casually excuse the house organ from obedience to the economic facts of life? Who's to blame? Many communications experts place the blame squarely on management's shoulders. In too many instances, they claim, management actually won't let employe publications do a good job. As one put it: 'Many employers give the impression of insincerity in telling their stories, use ineffective methods, inform employes too late, or never get around to informing them at all.' "

Downward communications stands fairly well up on the list as an area for improvement. The lower degree of satisfaction indicated by engineers may mean that management performance on communications is not as satisfactory as people in upper levels of management think it is.

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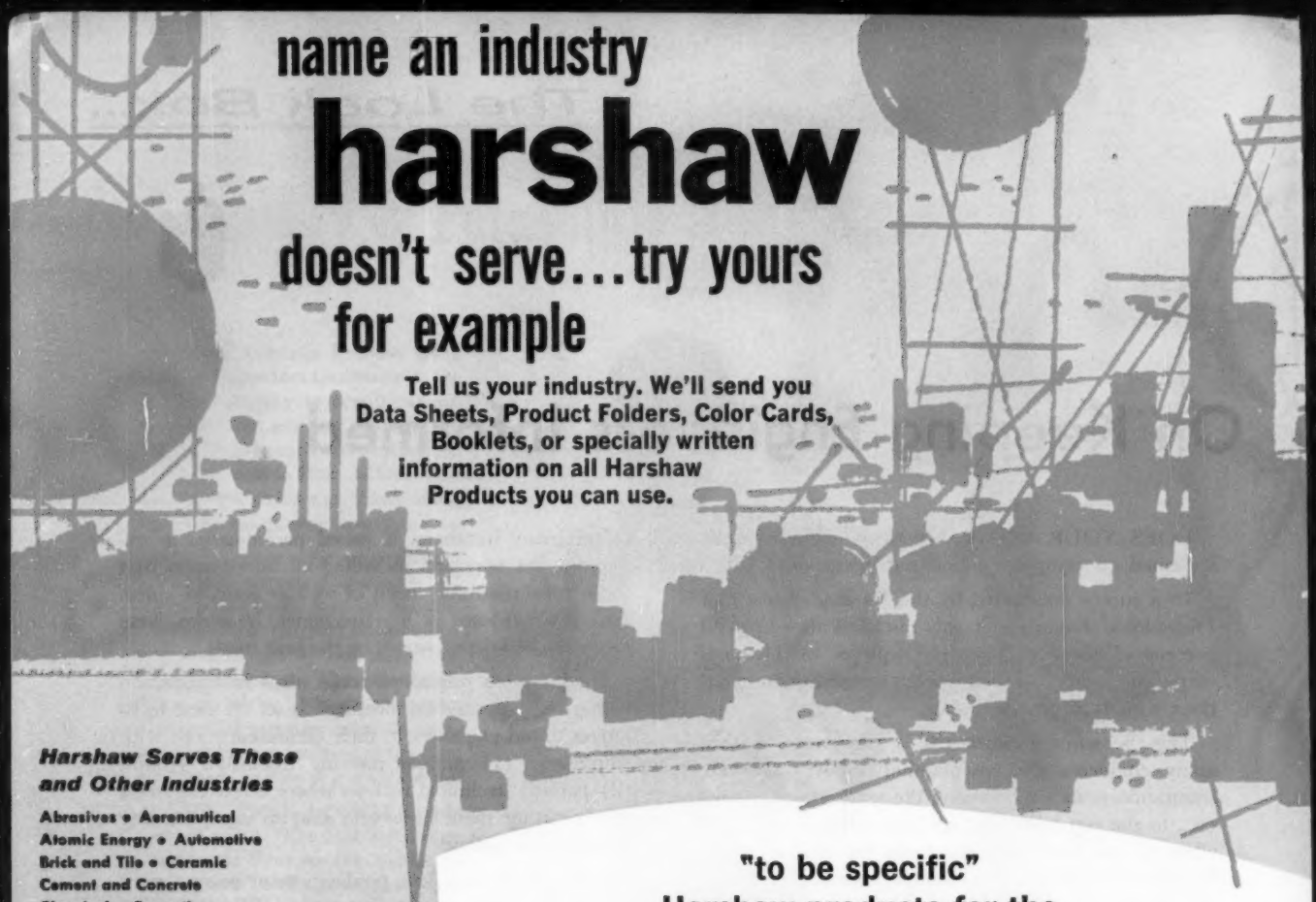

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Some More Green Cheese

WHEN PROPAGANDA MILLS begin to turn and keep turning, a people—particularly if an iron curtain separates them from other nations—cannot be blamed for getting and holding onto some strange ideas.

"Izvestia," official publication of the Soviet government, last May printed an article about America's "1200 Du Ponts," who, it said, are "multiplying with the speed of cancer cells." Their "villas and mills, plantations and hotels, factories and night clubs, large enterprises and entire cities," it declared, "all were stolen from the people."

Overlooking the thousands of items which Du Pont ingenuity, research and scientific know-how have developed, "Izvestia" chooses to damn this great and progressive institution, founded and developed upon the American principle of free enterprise, by calling them "cannon kings" and going on to say that "the present directors of this monstrous company of death see as the only meaning of their existence the manufacture of the instruments of death and the making of dollars, each of which has on it a lump of dirt and traces of blood."

The Kremlin, including "Izvestia," knows with certainty, as pointed out in "Better Living," the Du Pont Employes Magazine, that "Du Pont's military sales are almost nil" and that "Du Pont's outside work for the U.S. government is done virtually at cost."

Another of the jokers played by the Russian editors in this sorry yet ghastly game is that "Du Pont's wish is the law in Washington."

That statement alone indicts this entire "Izvestia" article as well as the continuing propaganda Soviet barrage for being the lies they are. Du Pont and our Supreme Court recently went round and round on the matter of General Motors stock holdings and if Du Pont's control of the court was evident in the final decision, then not only the moon but Khrushchev's left eye both are made of green cheese.

That's the main purpose of this discussion, viz., to publicize one of the latest "made in Moscow" samples. But it might well include this thought:

There are too many people, including government officials, in our own national capital who, in their pronouncements about business and industry handle the truth with nearly as much reckless abandon as do our Muscovite propagandists. The continuous sniping at business, particularly big business—and Du Pont seems to be one of their main targets—does our national economy and confidence no good. Most of the pot-shots are politically motivated, have every earmark of brash demagoguery that should not be tolerated on the American scene.

So while pointing to the dangers of the forest that is Russia's propaganda, right thinking Americans might well give thought to the need for some major pruning in our own Big Thicket on the Potomac.

Wish I'd Said That!

SELDOM A DAY PASSES but that one engaged in some segment of the profession called journalism, as he reads a communication produced by another, doesn't say to himself, "I wish I'd said that." Good, sound thoughts sometimes are like a dream at dawn—quite elusive, and difficult to re-recreate sufficiently for a word-on-paper account. Then comes along, and not infrequently, in one's reading some fellow's printed product that shows he was able to cut through all the hazy mental barriers and come back with the gem—the one you wish you'd beat him to.

ITEM 1—"I say this in full realization that there are two conflicting ideologies in our world today, each championed by a great nation armed to the teeth. We dare not lose that conflict. But some way other than sheer financial extravagance has got to be found for the quite simple reason that whether you are murdered or commit suicide you are nevertheless dead." —Robert C. Tyson, chairman, Financial Committee, U. S. Steel Corporation.

ITEM 2—"More scientists and engineers are being trained than ever before, more funds are allocated to research, more organized teamwork is being applied to finding new products and processes; and with speedier communications these discoveries are more quickly disseminated world-wide. Considerable change once took considerable time, usually more than a single lifetime. Generally, mankind could start from relatively fixed conditions and adapt over a few lifetimes to important changes. Not so today. The son no longer lives in his father's world."—M. J. Rathbone, president, Standard Oil Co. (New Jersey).

ITEM 3—". . . Federal spending programs handled by the backdoor method are not subject to the annual scrutiny of Congress. Once a federal agency is authorized to borrow to carry out a program, it does not have to justify its expenditures to subsequent sessions of Congress. In effect, then, the people lose a portion of their control over the way the national dollar is spent. That is *not* good business.

"It is a brutal fact of economic life that there is a limit to borrowing and that beyond that limit lies fiscal disaster. We must insist that the federal government recognize its responsibility in this light so that it may continue to serve the needs of the people to whom it owes its existence."—The Standard Oiler (Standard Oil Co. of California magazine.)

Responsible leaders are demanding sound policies and practices from government and the sensible cooperation of industry and labor in matters of wages and prices. We can help if we keep in touch with what is going on in government . . . study the records of representatives in Congress and at other levels . . . and make informed decisions as to which party and which candidates are best fitted to lead this country.

—Eric Schram, former president
New York Stock Exchange

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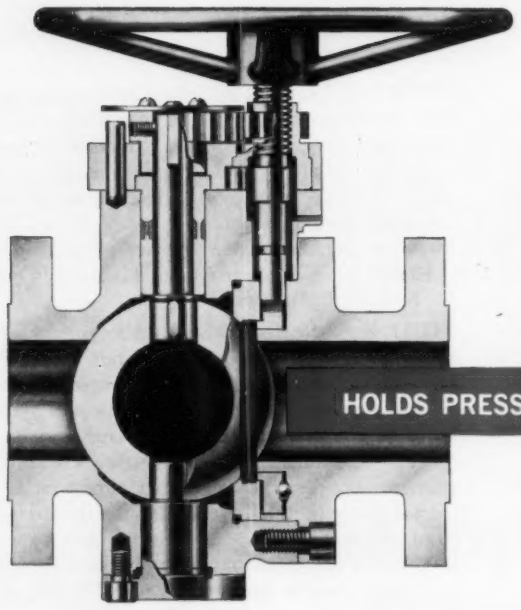

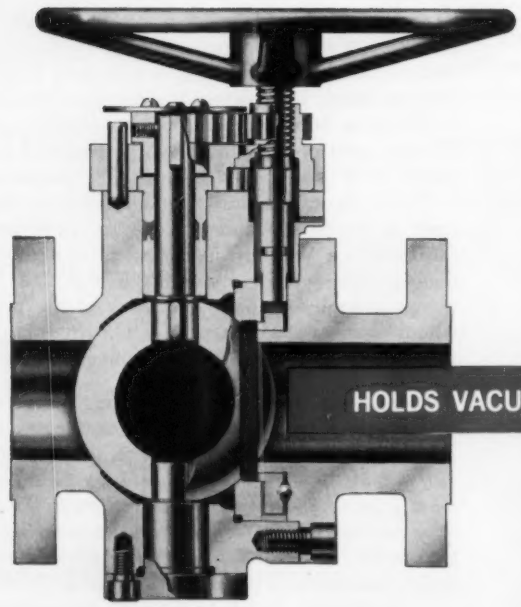

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Controlled sealing . . . a new concept in valve design . . . is the secret of Hydril's tight, bubble-proof shutoff. Hydril Ball-Plug Valves always seal positively against pressure from either direction—or against vacuum—because the fully confined packing ring is mechanically compressed between plug and seat when the valve is closed. This tightly compressed gasket type seal easily bridges clearances between parts as well as surface imperfections. Result: seal efficiency is unimpaired by prolonged hard usage, by rust or sediment.

Design of Hydril Type "K" Ball Plug Valves assures minimum maintenance costs. Non-lubricated, they employ no sealing lubricants. There's no sliding friction between plug and body to produce wear and abrasion.

The spherical plug is mounted on accurately positioned bearings, maintaining a minimal controlled clearance between plug and body. This contributes to easy, free-turning operation as well as to long service life.

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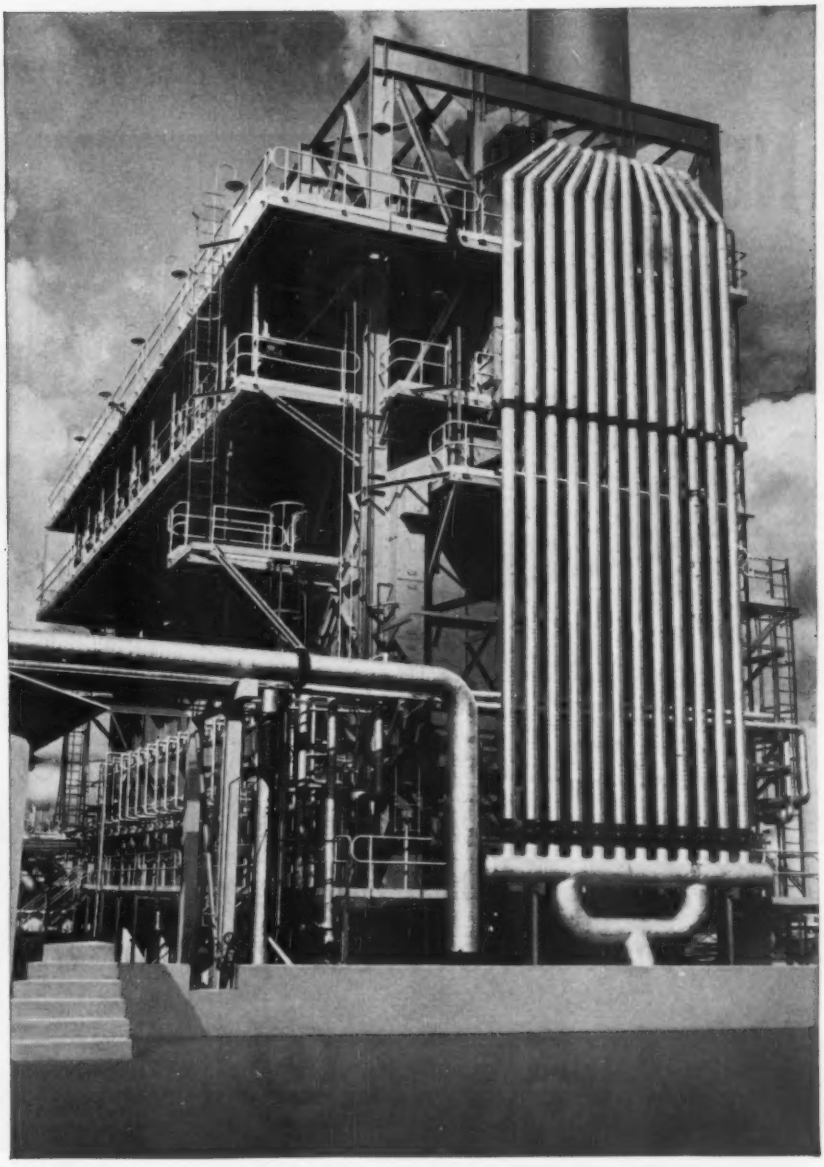
Experience this big goes into all of our smaller heaters



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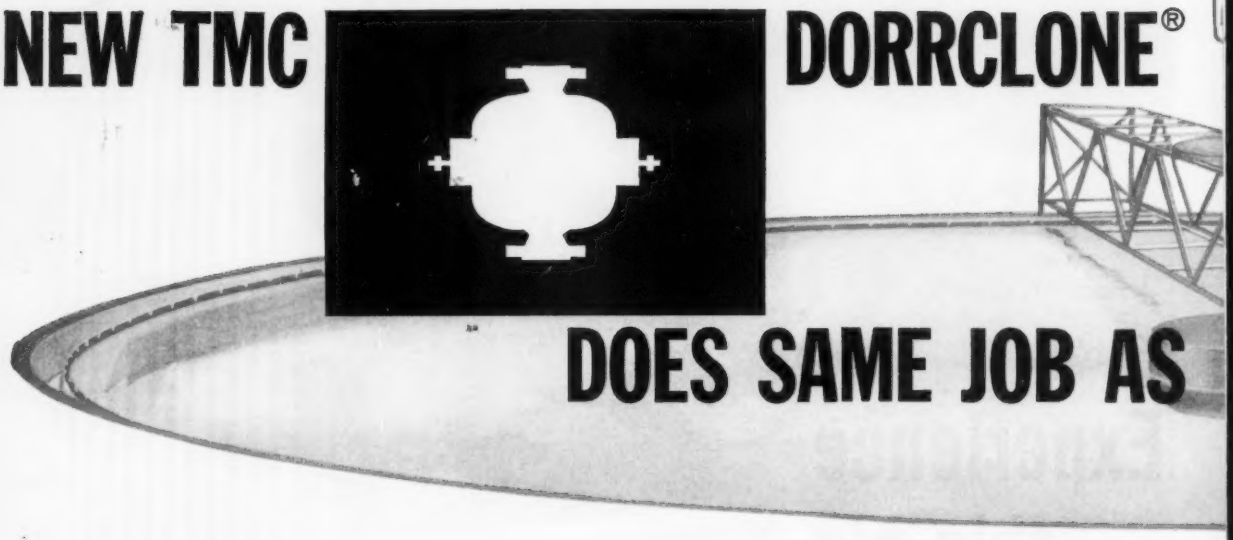

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TMC DorrClone with midget manifolded cyclones handles entire bottom stream... up to 10,000 bbls/day in new or existing installations... can pay for itself in a month!

The TMC DorrClone is a major new tool for refinery processing. Initial installations prove beyond question that it offers sensational opportunities for important cost savings.

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SPECIFICATIONS	TMC-60	TMC-180	TMC-300
Capacity, bbls/day	1000-2000	4000-6000	7000-10000
Height, inches	17	24	30
Diameter, inches	22	32	40
Weight, lbs. (approx.)	1100	1800	3000
Pressure, psig	150	150	150
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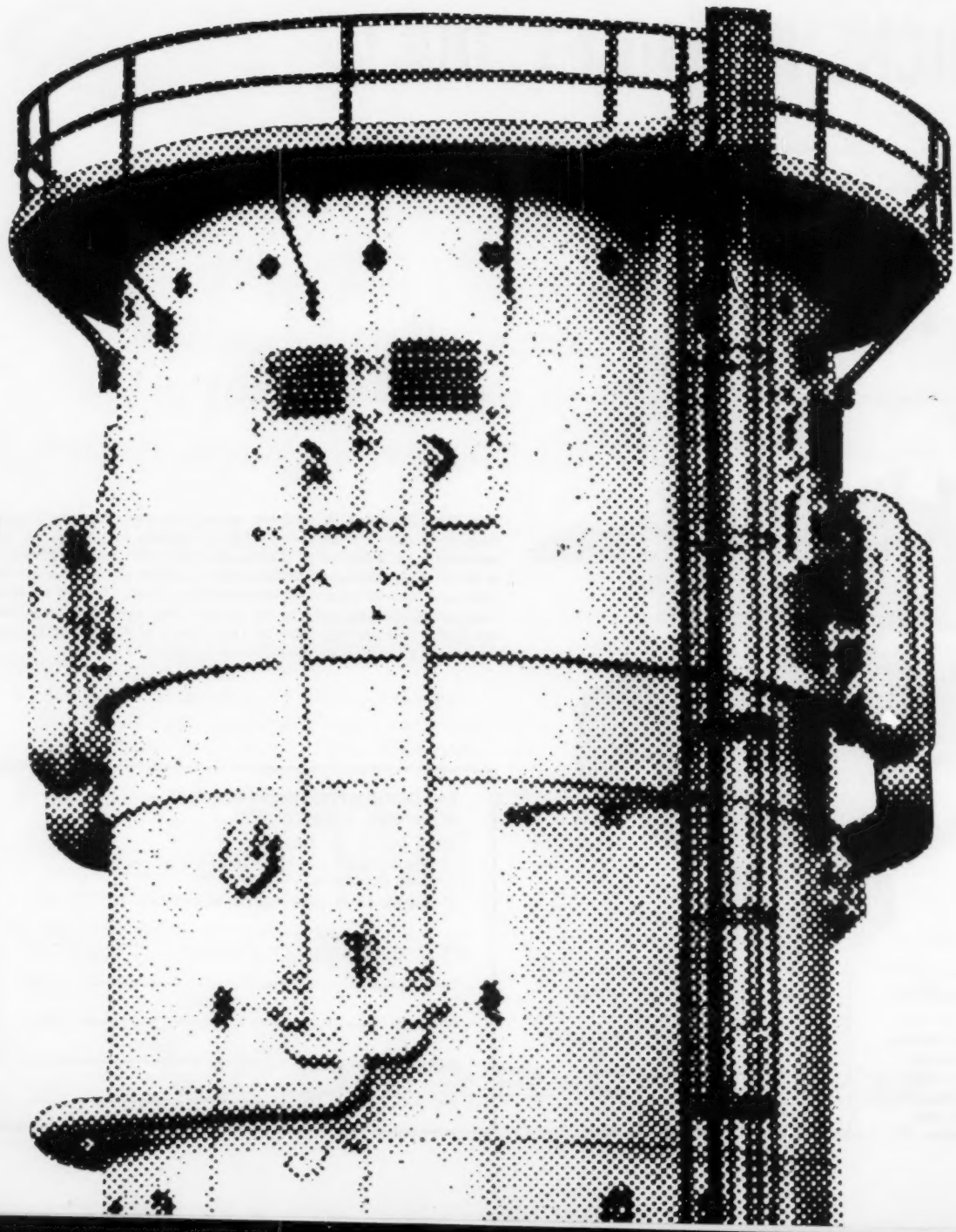

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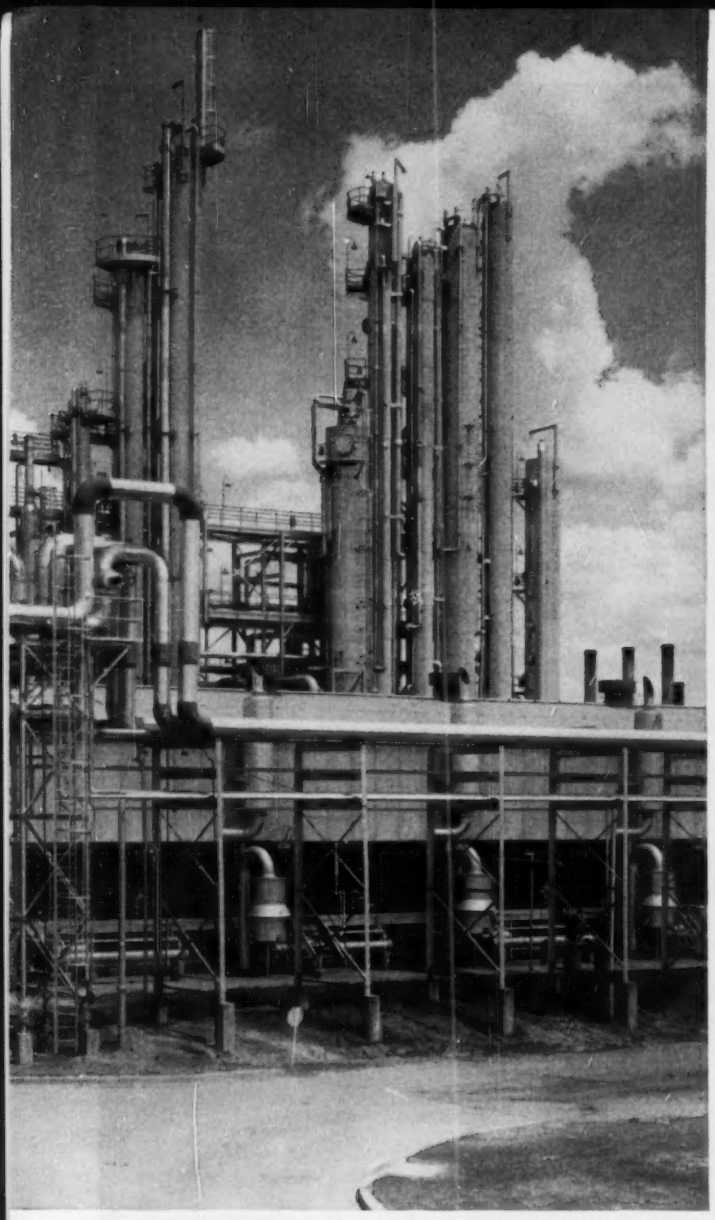
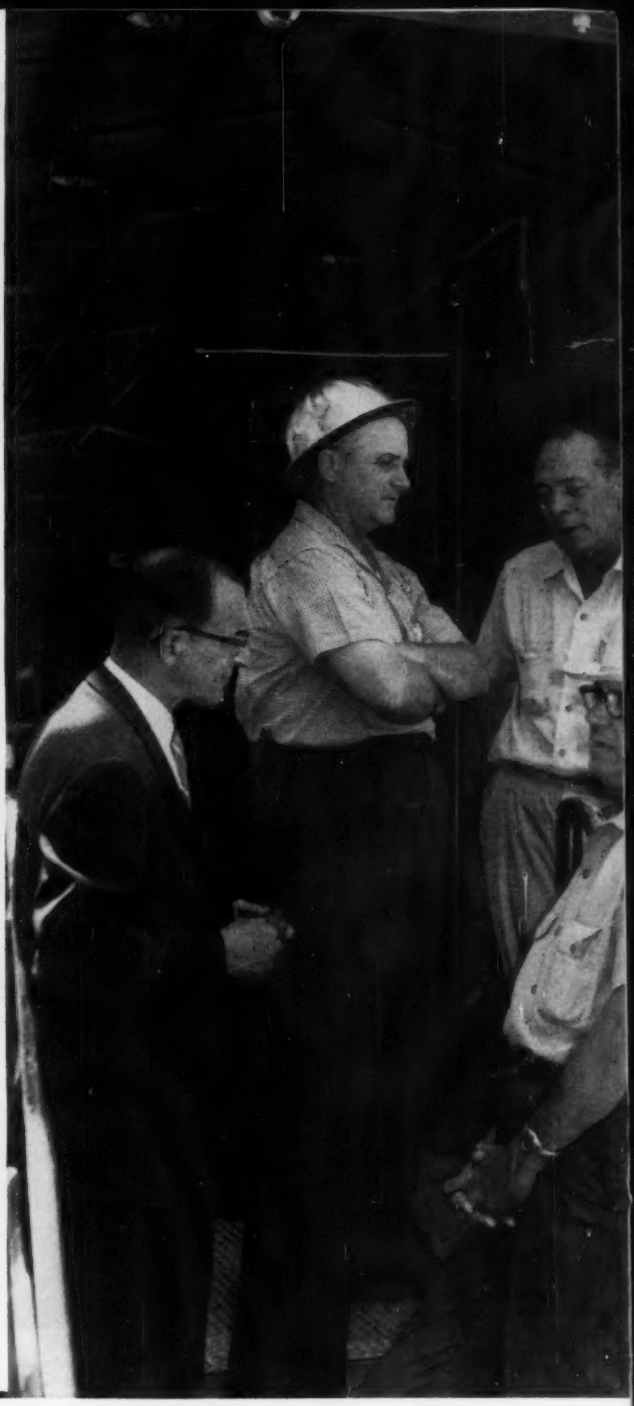


Hydrocarbon cracking plant produces ethylene and propylene for polyethylene and polypropylene plastics, ethyl alcohol and aldehydes. Compressor building in foreground houses 5 Cooper-Bessemer GMV compressors. In an adjacent building are 5 GMVA units.

Discussing a project involving additional compression facilities: Foreground, left to right: C. W. Woltz, Manager of C-B's Shreveport office; E. R. McWhorter, Assistant Superintendent of Texas Eastman's cracking plant. Background: Nelson Barksdale, Maintenance Supervisor of Texas Eastman's cracking plant; Joe E. Geurin, Service Engineer of C-B's Shreveport office.



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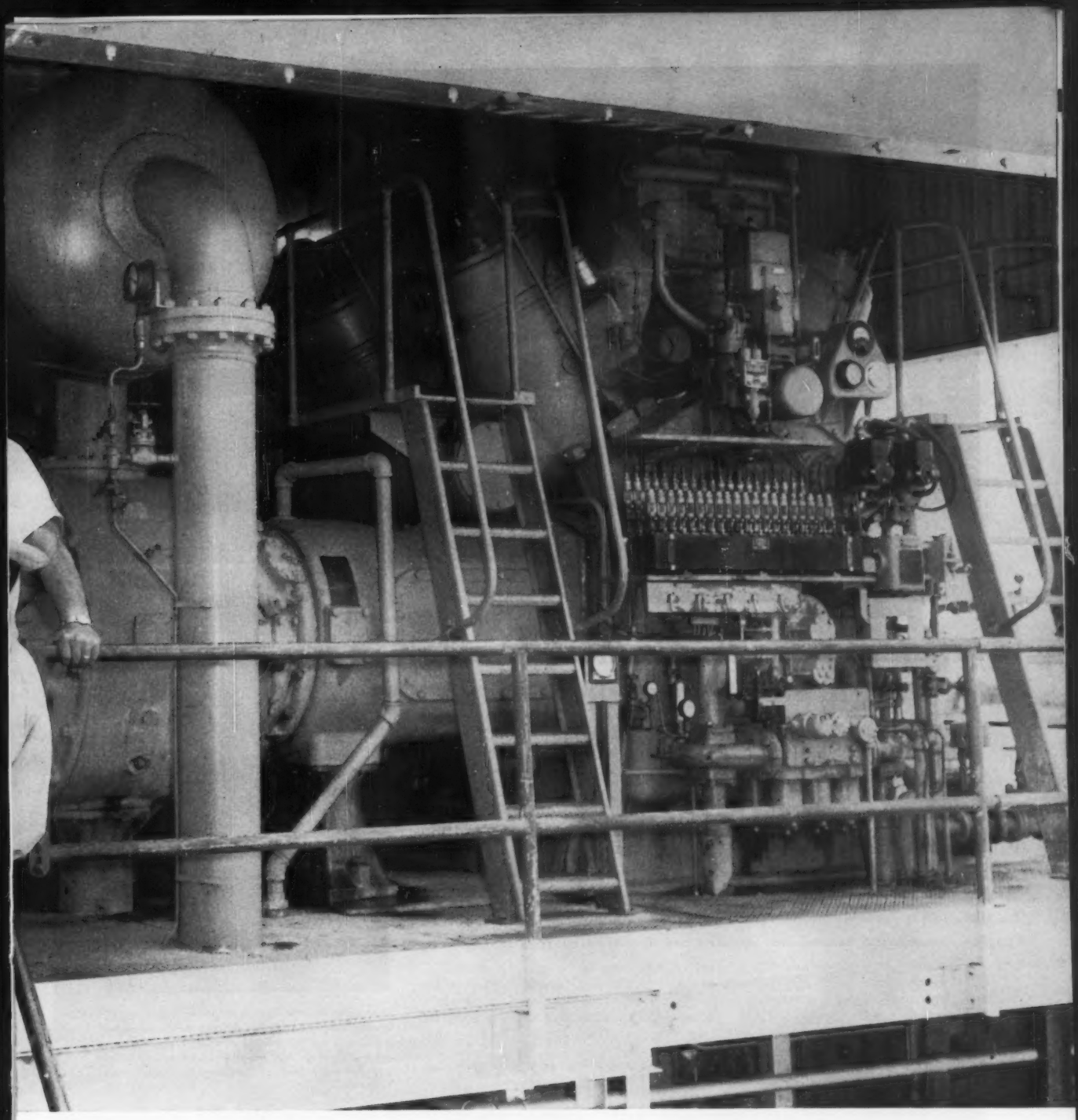

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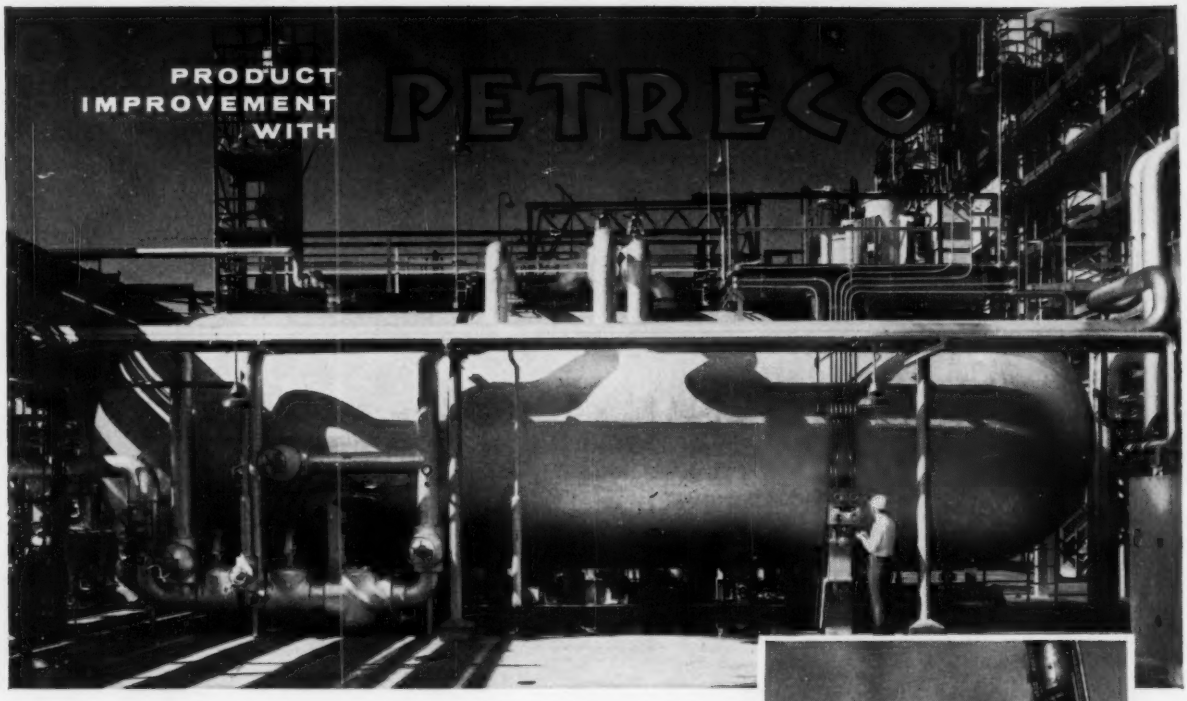

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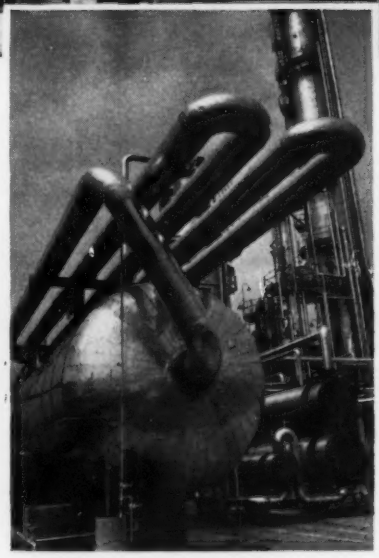
Because Petreco offers both types of desalters, you get an objective appraisal of the method best suited to your operation.



Operating records from installations such as these, around the world, prove that no other desalting equipment on the market can offer you comparable efficiency. And no other company can offer you Petreco's fund of desalting technology and experience.

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The job is producing acrylonitrile from natural gas . . . and sixteen Clark centrifugal compressors play a vital role in getting it done. Installed at the Fortier, La. plant of American Cyanamid Company, they have been in continuous service since startup.

Shown above is a battery of seven Clark units handling air in the main compressor building. Elsewhere in the plant, Clark centrifugals are compressing hydrocarbon gases and nitrogen for other phases of the process.

In addition to unusual reliability, several important operating characteristics of Clark compressors influenced American Cyanamid's choice: Their design permits diaphragm or injection cooling for temperature control and greater safety. Dependable, adequate sealing systems have been developed and are available for specific requirements. Integrally supported bearings minimize the bearing span, permit the use of a greater number of impellers, and assure permanent alignment.

Highly regarded in the expanding petrochemical industries, proven Clark centrifugal compressors are operating in a wide range of processes throughout the world. They are at work in ethylene, acetylene and butadiene plants, as well as numerous other applications which require gas compression, air compression, low temperature refrigeration, vacuum, and other services.

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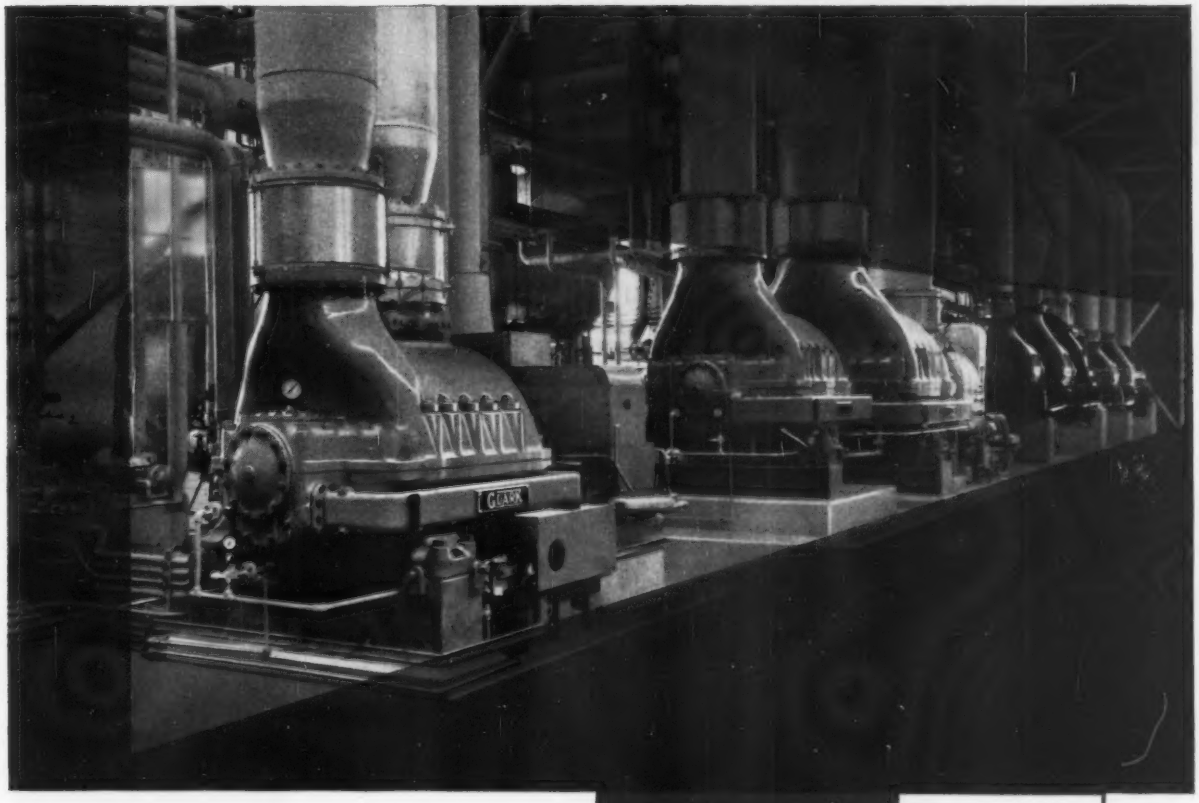

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AT COSDEN . . .

After five years' experience in operating Combin-aires, Cosden Petroleum Corporation, at its Big Spring refinery, has installed its FOURTH Hudson Combin-aire.

The Combin-aire is an integrated structure combining a water cooling tower with fin-tube hot fluid to air exchangers. Ambient air is cooled as it is drawn thru the water, and the cooled air serves as the cooling medium for the fin-tube coolers. Thus, with fin-tube coolers, effluent process stream temperatures may be reduced far below those obtained with ambient air.

The Combin-aire may be used primarily as a cooling tower, with the advantages of double use of air, and, because hot effluent air is undersaturated, complete elimination of spray carry over or condensation. Or when water is scarce, or salt, or brackish the Combin-aire may be used primarily for fin-tube cooling, using minimum water of any quality for pre-cooling air.

DEPENDING UPON DESIGN OBJECTIVES THE COMBIN-AIRE MAY HAVE SOME OR ALL OF THE FOLLOWING ADVANTAGES:

- Absolute minimum water consumption consistent with attainment of low terminal process stream temperatures.
- Water circulation may be made automatically responsive to air temperatures with no water circulated except at high ambient temperature.
- No water treatment necessary. Salt water or brackish water may be used.
- No spray carryover or condensation. After passing across the fin-tube elements the heated air leaving the Combin-aire at elevated temperature is undersaturated with water vapor and cannot precipitate condensate or carry water spray.
- Minimum piping. Combin-aire may be installed immediately adjacent to other process equipment.
- Clean air to fin-tube units. During the hot season air is washed, removing dust, sand and insects.

Effluent temperatures of process streams may be accurately controlled with HUDSON Auto-variable pitch fans.

HUDSON

ENGINEERING CORPORATION

BRAEBURN STATION • HOUSTON, TEXAS

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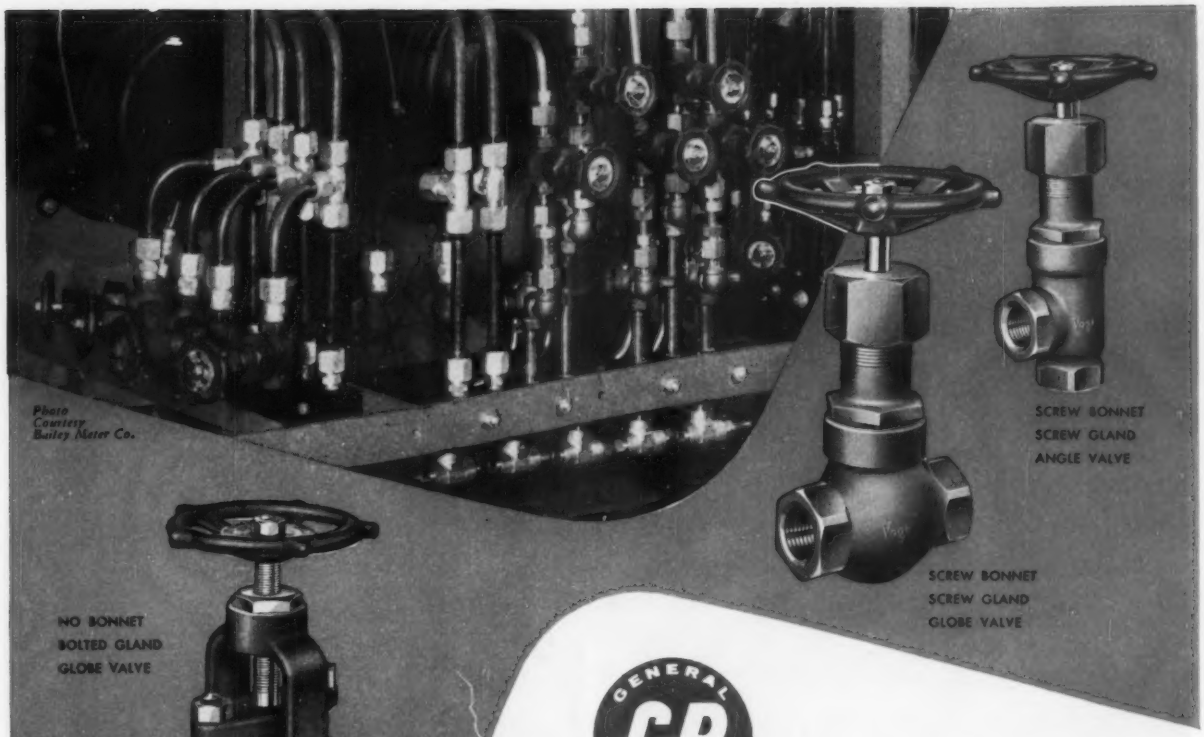

GENERAL GP PURPOSE

FORGED STEEL *INTEGRAL SEAT* METER AND GAUGE LINE VALVES

Union Bonnet, Screw Bonnet and No Bonnet Types

Service proved Vogt GP Forged steel valves are the choice of leading meter and gauge Manufacturers for top performance and unfailing reliability.

They are available in sizes from 1/4" to 2" of carbon steel for general purpose duty and of all-stainless where highly corrosive liquids are involved. All stems are one-piece 13% Chrome Stainless Steel with fine pitch threads for accurate regulation of flow. Special packing is furnished when specified.

Catalog F-10 contains the complete Vogt line of valves, fittings, flanges and unions. Available upon request on your letterhead. Address Dept. 24A-FPR

HENRY VOGT MACHINE CO., P. O. Box 1918, Louisville 1, Ky.

SALES OFFICES: New York, Chicago, Cleveland, Dallas, Camden, N. J., St. Louis, Charleston, W. Va., Los Angeles.

Vogt FORGED STEEL **VALVES, FITTINGS, FLANGES and UNIONS**

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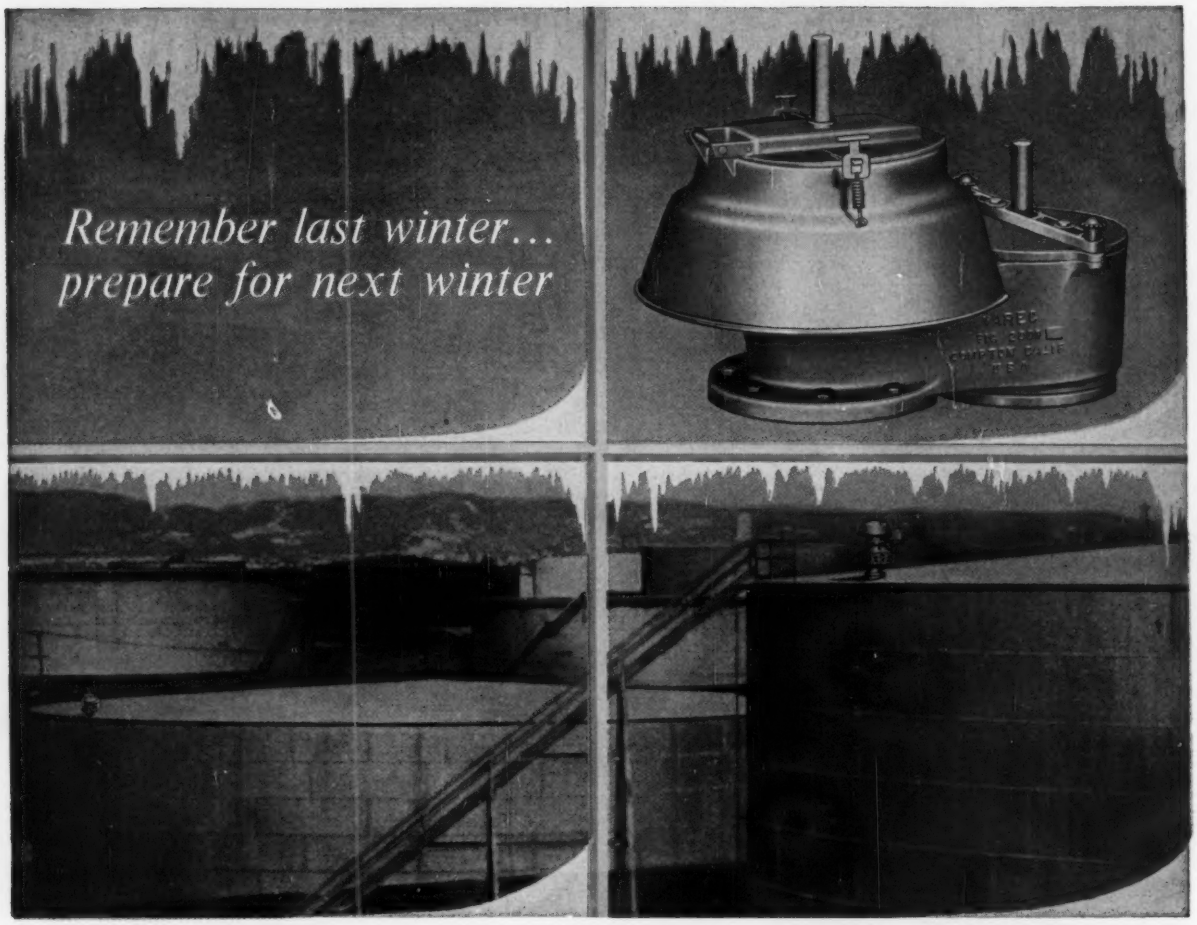

MODERNIZE YOUR TANK FARM NOW

with the new Varec <u>All-Weather</u> Breather Valve that works perfectly in -60° winters and +125° summers.

Here's all-weather performance that's been *proven* through two full years of Eastern Canada's roughest climate...frigid winters...hot, humid summers. Yet never once did Varec's rugged new Fig. 2000-61 ALL-WEATHER Breather Valve fail to operate perfectly. What's more, this petro-chemical plant can look forward to the continuation of this 100% performance for many tough seasons to come.

By modernizing your tanks with this new Varec ALL-WEATHER Breather Valve, you are now assured of tank safety and vapor saving efficiency *the year around.*

NEW FIG. 2000-61 MODEL...
TWO-WAY PROTECTION AGAINST FREEZE-UP.

Here's how Varec engineers have solved the cold-weather problem: First, both pressure and vacuum pallets utilize a flexible diaphragm of special non-frosting, icing-resistant material. This eliminates possible freezing between pallet and seat ring.

Second, a special non-frosting, icing-resistant compound is used to coat the pallet perimeter and stem, guide-posts and tip of seat ring. Ice and snow scrape free when the pallet lifts.

For complete information on the Varec Fig. 2000-61 ALL-WEATHER Breather Valve, write for Varec Bulletin No. CP-2701, Dept. PR-1500-6.

"Varec"
TRADE ® MARK

THE VAPOR RECOVERY SYSTEMS COMPANY
2820 North Alameda Street • Compton, California

Branches and Representatives in Principal Cities

"K&M" ZEBRA Pipe Insulation *proves its toughness before it leaves home!* In torture tests by hard-to-satisfy K&M engineers, "K&M" Zebra® proves its ability to withstand heat, shock and vibration. Its multi-layer, sectional-type construction of calcium-silicate—asbestos bonded felts requires no babying on the job. Demonstrates a deflection at breaking point 2 to 4 times that of ordinary insulation. Stands up under periodic removal for line inspection. "K&M"® Zebra Pipe Insulation prevents heat loss indoors and outdoors, through a temperature range from 200 F to 1200 F. Its smooth, dust-free surface facilitates handling (no skin irritations or penetration). Half-sections and sizes available through 24″ pipe diameters. For more information, write: *Keasbey & Mattison Company, Ambler, Pa., Dept. I-2101.*

K·M
BEST IN ASBESTOS

Keasbey & Mattison at Ambler

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FOR QUALITY... PRODUCTIVITY ...PROFIT

INSTRUMENTATION FOR AUTOMATION

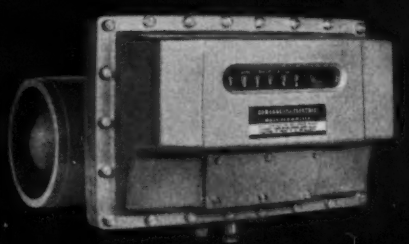
PROBLEM: how to collect, record and transmit critical fluid flow data more *accurately* than ever before.

SOLUTION: custom-designed flow measurement systems from General Electric.

RESULT: reliable process control, simplified fluid accounting, precision batch blending and loading.

System instrumentation includes: true mass flowmeter, available in 13 standard ranges ■ null balance recorders, a full line of strip and round-chart ■ new telemetering equipment, analog and digital.

In addition, ticket printers and totalizing counters are available for visual digital display and pre-set counters may be added to provide precision control in blending and loading operations.



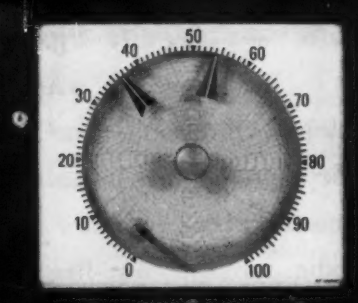
Mass Flowmeter measures fluid flow directly in pounds, eliminates volume-to-mass conversion. ±1% accuracy unaffected by change in pressure, density, temperature, viscosity, flow rate. 13 standard ranges now available.

FOR FLUID FLOW PROCESS:

HIGH ACCURACY

In a variety of system applications, these General Electric instruments cut operating costs and boost plant production . . . through *simplified* and *more accurate* measurement. No wonder they've been specified by process engineers throughout the world. *Performance-proved . . . on the line!*

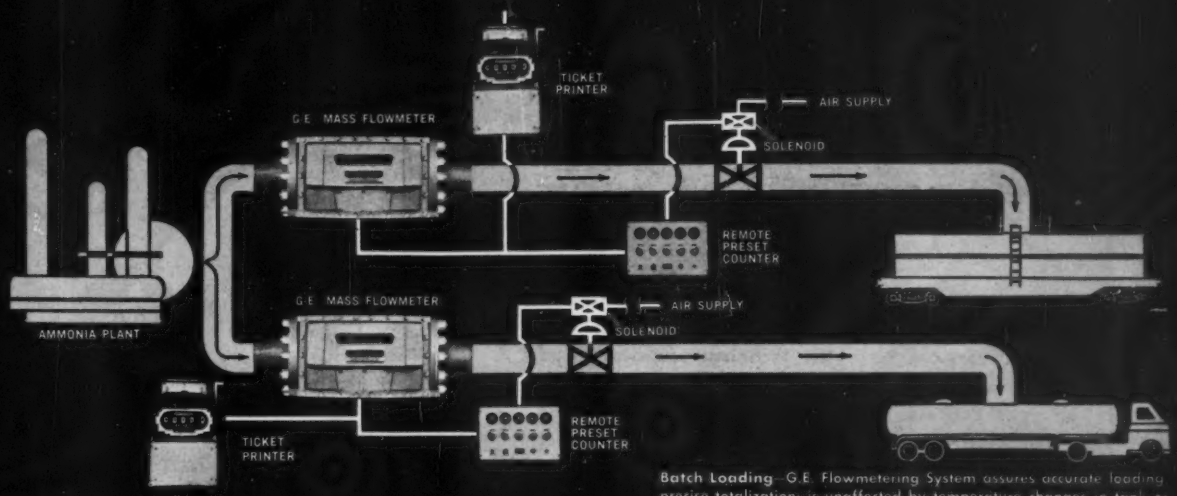
For complete information, contact your nearby General Electric sales office or write Section 599-08, General Electric Co., Schenectady 5, N. Y. for the following bulletins: GEA-6925, Mass Flowmeter; GEA-6887, Null Balance Recorders; GEA-7163, Telemetering Systems. In Canada, contact Canadian G.E. Co. Ltd., 940 Lansdowne Ave., Toronto 4, Ontario. Outside the U.S. and Canada, contact International G.E. Co., 150 E. 42nd St., New York 14, N. Y.



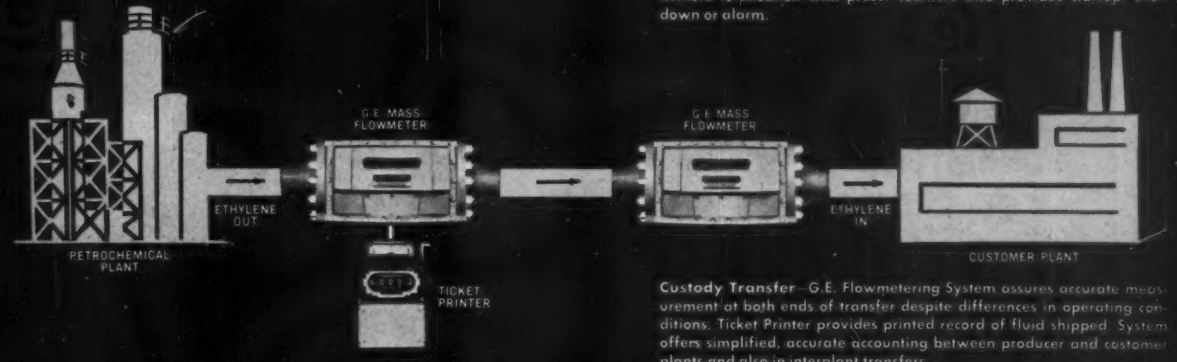
General Electric Null Balance Recorders feature: silicon diode reference voltage source for operational reliability; varied control forms for versatile applications; components mounted on swing-out panel to simplify routine maintenance. Full line includes multipoint, single and two-pen—strip or round-chart models.

INSTRUMENT DEPARTMENT

GENERAL ELECTRIC

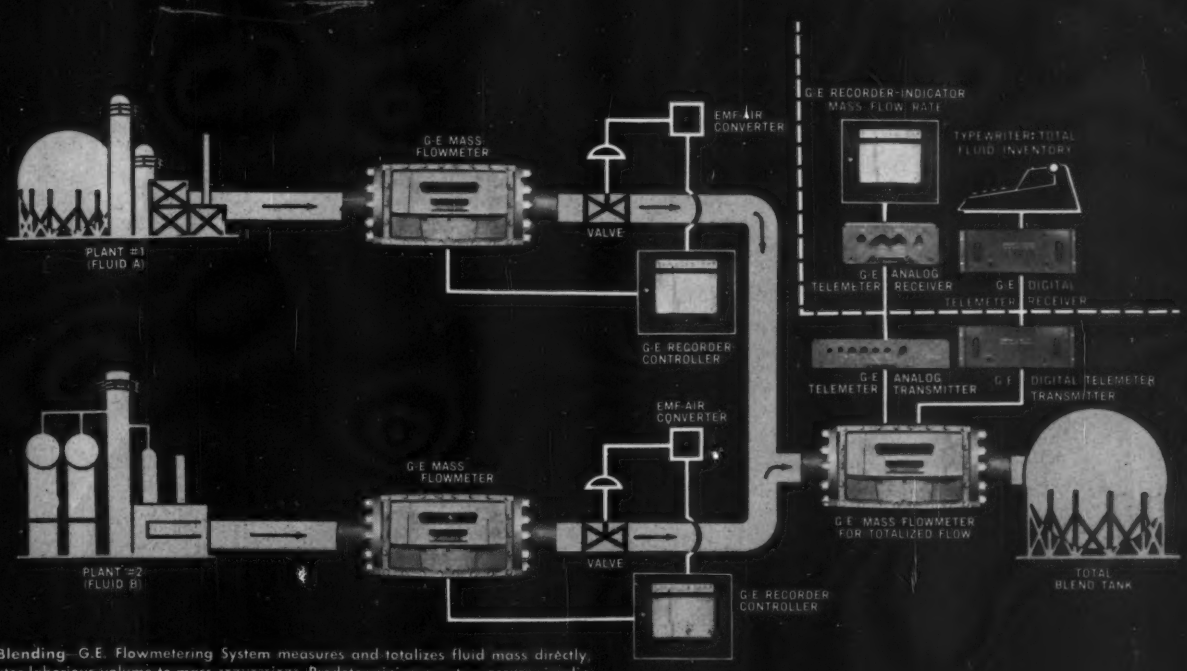


Batch Loading—G.E. Flowmetering System assures accurate loading, precise totalization; is unaffected by temperature changes in tank or pipe. Meter measures different fluids with no calibration change. Remote totalization with preset counters also provides startup, shut-down or alarm.



Custody Transfer—G.E. Flowmetering System assures accurate measurement at both ends of transfer despite differences in operating conditions. Ticket Printer provides printed record of fluid shipped. System offers simplified, accurate accounting between producer and customer plants and also in interplant transfers.

MEASUREMENT SYSTEMS FROM GENERAL ELECTRIC



Fluid Blending—G.E. Flowmetering System measures and totalizes fluid mass directly, eliminates laborious volume-to-mass conversions. Predetermining counters assure simplicity and accuracy in blending operations. Data is instantly telemetered to central locations by new G-E Telemetering. Typical blends are refrigerants, solvents and special naphthas.

IF IT'S BY CHIYODA IT'S BOUND TO BE GOOD

By "Good" we mean that CHIYODA's Process Plant Specialists (Engineering, Fabrication and Construction) have the technical know-how and modern, completely equipped facilities to handle your Process Plant needs and problems—large or small—from drawing-board to finished product and produce the results that count: Peerless quality, competitive prices and early delivery.

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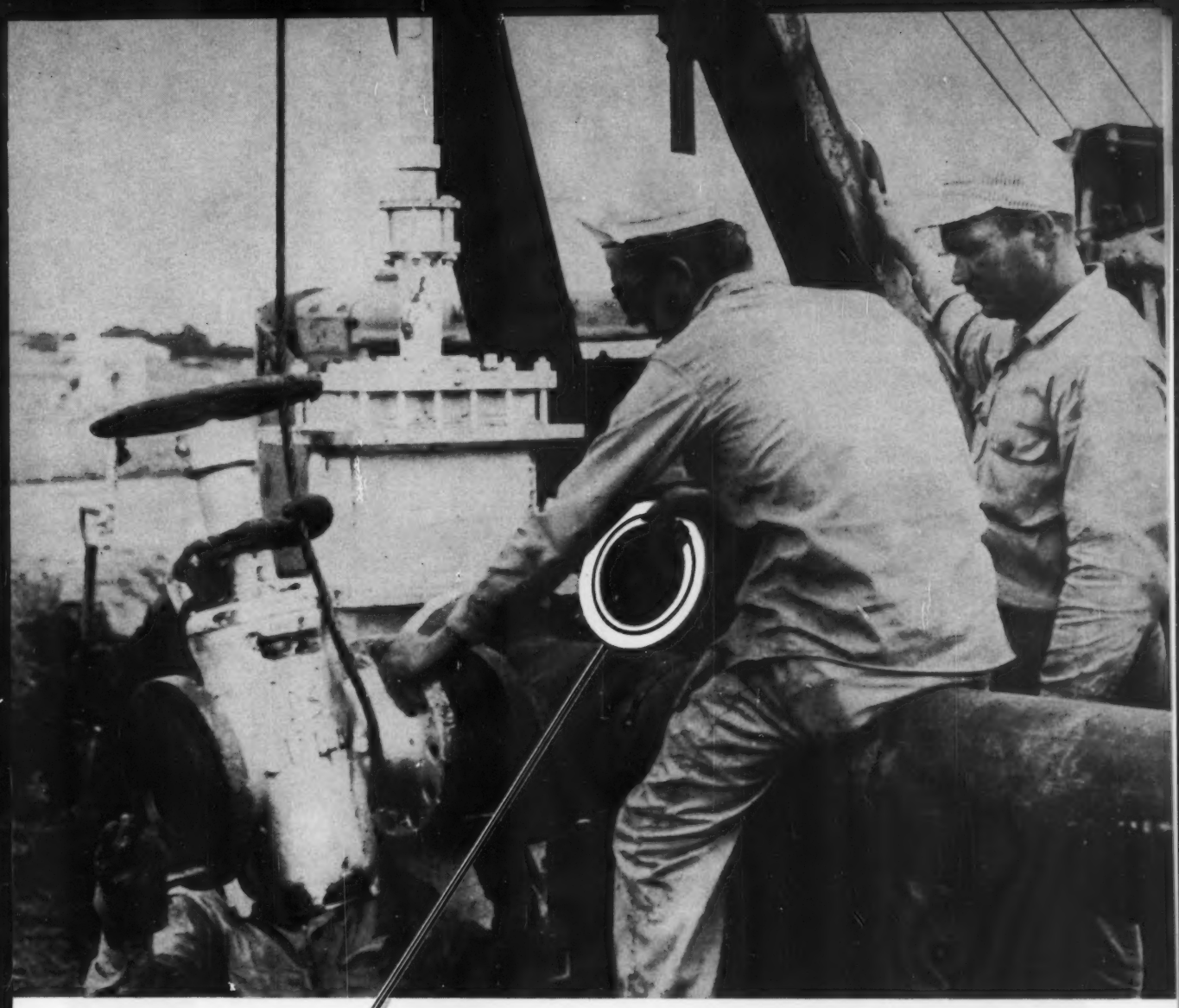


More Than A Gasket . . . It's Safety and Reliability Plus Re-usability!

Yes, Gask-O-Seals do cost a little more (but very **little** more) than ordinary gaskets . . . **But** they save a **lot** more in time and effort. For instance, they will tolerate flange deflection or bolt stretch; they will seal pressures beyond rated recommendations; they are fail-safe and will not leak or wear due to vibration or pulsing . . . and it is much easier and quicker to install a Gask-O-Seal. More and more pipe line engineers, refiners and processers are specifying Gask-O-Seals because of their superior reliability. Why not get the **facts** about these unique **no-leakage** gaskets.

LISTED UNDER RE-EXAMINATION SERVICE UL OF UNDERWRITERS' LABORATORIES, INC.

Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

Durable paints that keep uniform color

That's what you get when you specify paints made with M50® Basic Lead Silico Chromate pigment for your gas stations and tank trucks.

Keeping stations looking bright and inviting to customers can be a real problem. You can minimize this problem by specifying paints made with *M50*® Basic Lead Silico Chromate pigment—the pigment that puts anti-corrosion protection in every coat . . . plus weather resistance against fading and chalking.

M50 pigment provides "Defense-in-Depth"—keeps paint *uniformly* bright and attractive longer.

In addition to superior corrosion protection, *M50* pigment permits an *unusually wide range of color selection.* Paints made with *M50* pigment can be compounded in bright hues, soft pastels and other color variations to spruce up your gas station signs, pumps and tank trucks...make them attractive outdoor advertisements for your company.

Next time you buy paint for decorative metal protection, specify paints made with *M50* Basic Lead Silico Chromate – the pigment that puts anti-corrosion protection in every coat *and* provides durability, uniform resistance to weathering and wide color range.

M50 *an* **oncor**® *Pigment... A Development of* **National Lead Company**

General Offices: 111 Broadway, New York 6, N.Y.

The plug valve is obsolete . . .

replace it with the **FLO·BALL**®*!*

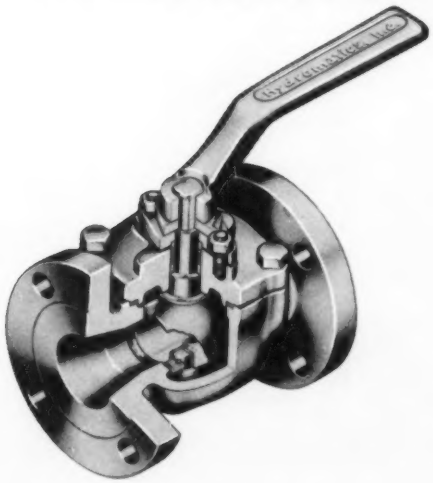
The plug valve era is over. They did a fair job while they lasted: easy to operate — 90° on-off — fewer parts than the bulky gate valves. They were expensive to maintain, but they were tight. There was one sore spot, however; maintenance was tough. It often cost more than the valves. Valves froze when they lacked lubrication. Replacing the plug in the field was impossible. Lubricant selection was difficult — contamination of process often took place. At low temperature, lubricants froze, so did the valves.

The **FLO·BALL** was created to solve these problems, still retaining the quarter turn and tight shutoff. The top and bottom guided ball is only in contact with self-lubricating teflon, eliminating lubrication. The **FLO·BALL** never leaks, never freezes, never galls . . . and the torque is the lowest in the industry. Seats seldom need renewing. If anything does happen, the top entry **FLO·BALL** valve can be serviced without removing it from the line, in a few minutes.

The **FLO·BALL** flow path is **always** round. There are no frictional flow losses due to cross-sectional change.

All in all, the **FLO·BALL** is a better valve than the plug. You owe it to yourself to fill your next valve application with **FLO·BALL**. Mail this card for complete information.

Fill in reverse side and mail today!



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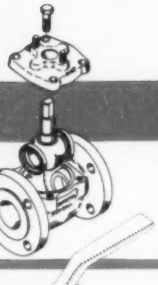
Compare FLO·BALL® feature for feature ... there is no equal!



	FLO-BALL	Ball Valve A	Ball Valve B	Ball Valve C	Ball Valve D	Ball Valve E	
1. TOP ENTRY All internal parts can be removed and re-installed without removing valve from line.	✓			✓			
2. TOP AND BOTTOM GUIDED BALL Provides truly double seal, extends seat life. Makes for easy operation.	✓						
3. DOUBLE SEATS Interchangeable and replaceable seats insure sealing in both directions; give double protection against leakage.	✓	✓	✓	✓	✓	✓	
4. FLANGES INTEGRAL WITH BODY Rugged, one-piece body design gives greatest possible strength.	✓	✓		✓			
5. ONE PIECE BALL AND STEM No possibility of separation of ball from stem. Always perfect alignment with zero backlash. Foolproofed for assembly.	✓						
6. BLOCK AND BLEED Top and bottom guided ball and floating seats provide simultaneous up-stream and down-stream seal . . . a true block and bleed valve. Block and bleed type available on special order.	✓						

Specify the FLO • BALL for your application

	SCREWED ENDS	FLANGED ENDS
Sizes	1/8" — 2"	1" — 36"
Pressures	Vacuum — 600# — 3000#	150# — 300# — 600# (ASA Rating)
Materials	Carbon Steel, Stainless Steels, Semi-Steel, Brass, Alloy 20, Monel	
Operators	Manual, Hydraulic and Motor	
Your Choice of FLO-BALL Types	Two-Way, Three-Way, Fire-safe, High Pressure (to 10,000 psi), Cryogenic, etc.	

Gentlemen:

I am interested in getting complete information on FLO-BALL valves.

My application is_____.

☐ *Send sales engineer* ☐ *Send literature*

Name_____ Title_____

Company_____

Street_____

City_____ State_____

1

FLO-BALL

Hydromatics, Inc.

BLOOMFIELD, NEW JERSEY

Fill in this card ... mail today!

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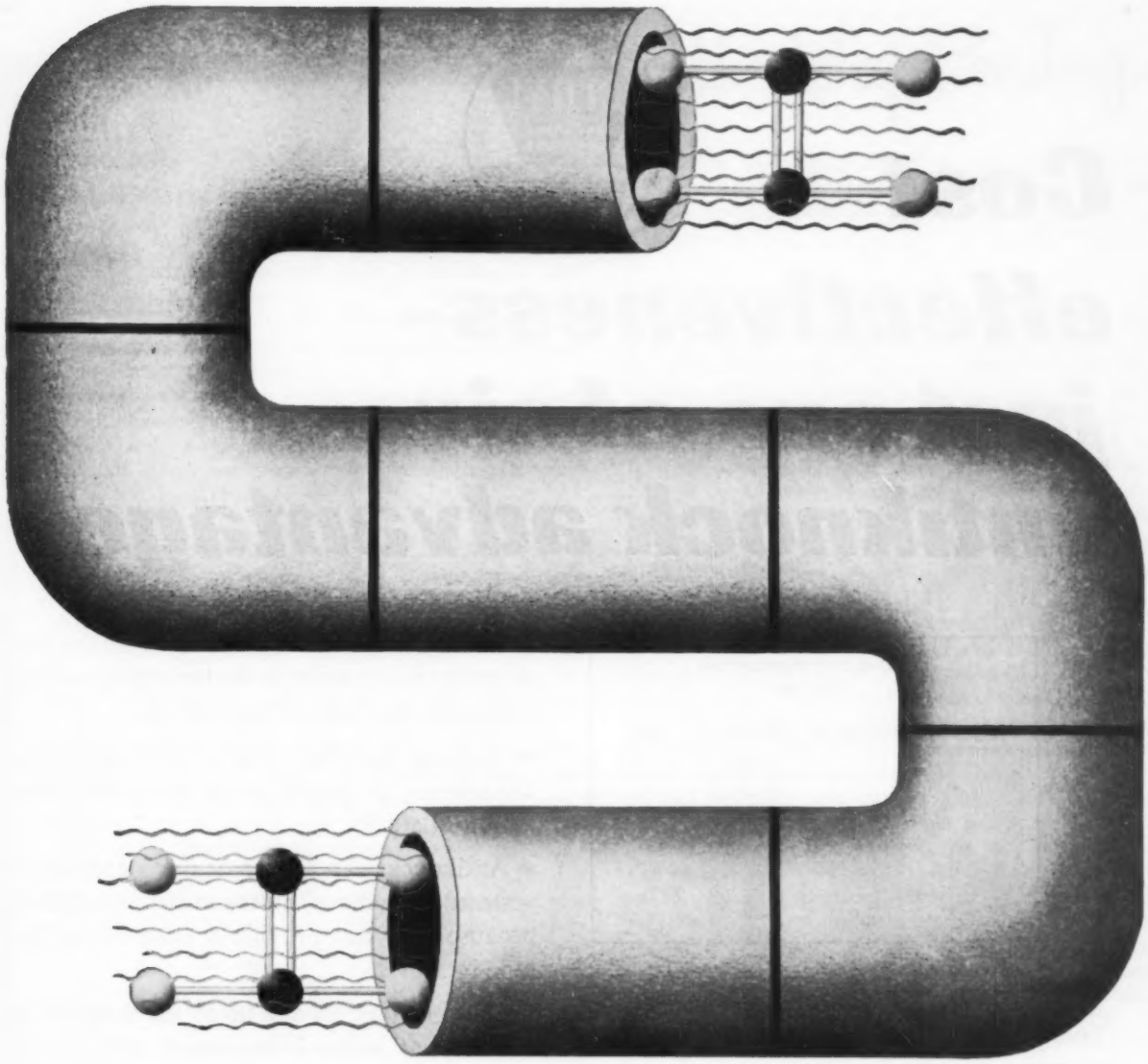

Minimum heat loss in transit

Caposite pure Amosite Asbestos moulded insulation is a material with extremely low heat transmission and great mechanical strength. It is cheap, light and very clean, and, though quickly applied, stays put permanently. That is why Caposite fulfills every insulation requirement in petroleum refineries and other plant where relatively slight heat loss could be critical.

CAPOSITE AMOSITE ASBESTOS INSULATION

Cape Insulation and Asbestos Products Ltd. *A subsidiary of The Cape Asbestos Company Ltd.*
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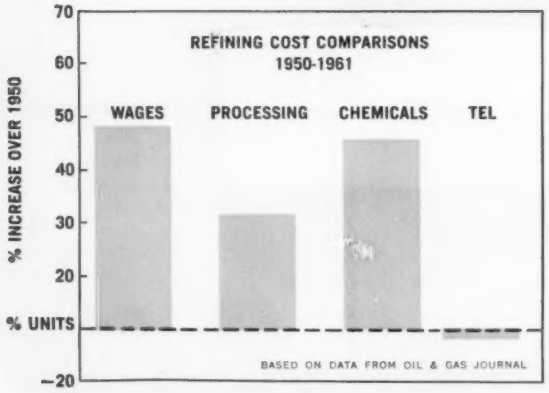
Enquiries to the above address or to: Cape Asbestos (Canada) Ltd., 200 Bloor St. East, Toronto, Ontario. Capamianto SpA via Sant'Antonino 57, Turin, Italy

TA 5110

Cost effectiveness– just one of six antiknock advantages



Today, more than ever, "Ethyl" antiknock compounds are your best octane-improvement buy—whether you figure cost on Research, Motor or Road ratings.

And also look at these added advantages:

- The range of antiknocks now available permits you to choose the one best suited to your special needs in terms of cost effectiveness.
- Antiknocks give you a road octane bonus you can't get any other way. This increases with higher lead concentrations.
- Decreased gasoline sensitivity from the use of antiknocks results in better engine performance, particularly at high speeds.
- Refining flexibility can be increased with antiknocks, to permit most profitable utilization of stocks.
- Antiknocks can reduce or delay capital investment in octane-improvement equipment because they can provide a cushion for octane increases.

These factors all add up to the need for a new look at octane-improvement costs and a reappraisal of the balance between antiknocks and processing.

Ethyl will be glad to help in evaluating your octane-improvement program. Linear-programming specialists will assist you in determining the proper allocation of components and optimum antiknock concentration, as well as selecting the most effective antiknock compounds from the wide range now available. Just call in your Ethyl Representative.

Ethyl Corporation

NEW YORK • TULSA • CHICAGO • HOUSTON • LOS ANGELES

ETHYL CORPORATION OF CANADA LIMITED, TORONTO • **ETHYL U. S. A. (EXPORT)** N. Y. 17, N. Y.

what's HapPeniug

TECHNOLOGY

Cosden starts using Clathration process

Union Oil's new Clathration process is being used by Cosden in 5-million-pound-per-year metaxylene plant. Process, which separates chemicals in accordance with their molecular configuration, was developed for para-xylene production by Union. Reforming's C-8 stream contains about 20 percent each of ortho and para-xylenes and 40 percent metaxylene.

Cosden's ethylbenzene fractionation process produces product mixed with paraxylene-metaxylene stream, which is being sent to Clathration installation. Result: Pure meta and 50-percent para stream, which then becomes para by fractional crystallization.

Better caprolactum polymerization

New caprolactam polymerization process announced in last month's "Quick Look at HPI," page 9, features extended properties useful in some completely new areas. Key to technique is new catalyst system, invented by Monsanto and developed by Polymer Corp. Details: Reaction takes place at atmospheric pressure, high temperatures. Polymerization occurs in about four minutes, with no removal of by-products or monomer. Thus, molding and polymerization take place in one operation, a useful process for forming big shapes directly from monomer.

Process's polymer is similar to nylon-6, but has higher crystallinity. Important factor is heat resistance (melting point, 430° F), while softening of product doesn't occur until only a few degrees from this. Key features: Resistance to fatigue and creep, absence of internal stresses.

New route to pure nitrogen

A new pure-nitrogen process that features useful pressures has been developed by Petrocarbon Developments, London. Technique involves raising entering feed air to 110-125 psig, and at only slightly lower pressure yields 99.999 percent nitrogen, without intermediate recompression. Process features refrigeration not obtained by usual expansion of feed stream. Instead, it expands nitrogen-depleted by-product from fractionation, which occurs at around —270°F.

Licensed in U.S. by Superior Air Products, method offers product directly available for distribution and use, without contamination-causing downstream compressors. Added feature: Completely automatic control, with output adjusting to demand. Product purity is continuously monitored. Look for plant to be built soon in U.S.

Quantum features new organic process

New process for commercial grade organic products with very high purity is in mill by Quantum, Inc. Continuous-zone freezing process offers feasible materials separations, heretofore thought next to impossible. Big feature: Lower refining costs in some instances, because of low energy requirements. Process is continuous and can be fully automated. Company claims compounds have done excellent purification job on carbon tetrachloride, benzene, ethylene glycol, acetic acid, and phosphorus oxychloride. Some purities have been more than 99.9 percent.

Attack on ozone cracking

Ozone cracking in some of the new synthetic rubbers, is under attack by Polymer Corp., which has found that an ethylene-propylene copolymer adds ozone resistance to several kinds of rubber products. This could be important development for manufacturers of tires subjected to harsh weathering. Elastomers such as butyl have built-in ozone resistance, and ozone-fighting qualities have been added to some other rubbers. Blending of elastomers, such as polyvinyl chloride, is being used in nitrile rubbers where petroleum waxes and anti-ozonants have been limited.

New aliphatic hydrocarbon process

Long-chain aliphatic hydrocarbons can be made via Quantum, Inc.'s new synthesis technique. Method was developed for Humphrey-Wilkinson, which uses Wurtz and modified Wurtz synthesis to make high-yield hydrocarbon waxes with 24 to 36 carbon atoms. Firm claims yields are 70 percent greater than with present commercial processes, and purities hit 97 percent.

The big picture: Process means waxes such as octocosane, hexatriacontane, tetracosane, and dotriacontane, can be made commercially. There is sometimes as much as 15 percent expansion when these compounds melt, making them very useful in thermosensing devices and thermostatic actuators. When they melt against a diaphragm, they offer positive displacement. Broad temperature-control range can be attained using different waxes.

PRODUCTS

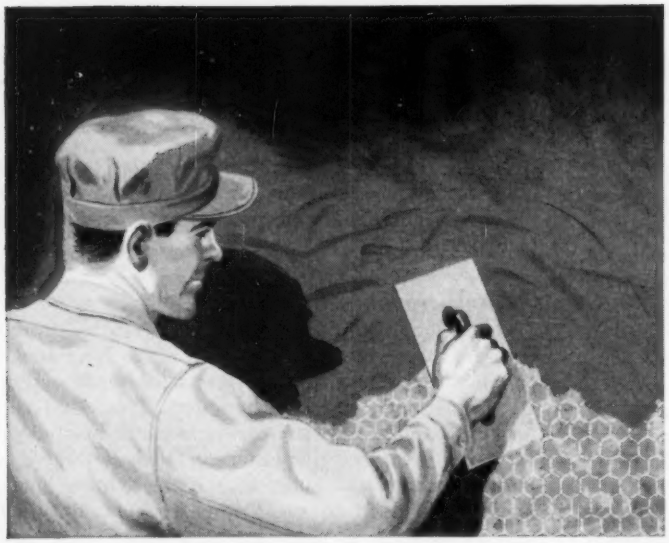
Goodyear features new diene rubber

Goodyear's new cis-polybutadiene rubber has revealed 35-percent increase in tread mileage for 50-50 blends with styrene-butadiene rubber in auto tires, according to company. Rubber blends in truck tire treads reveal 25-percent increase over conventional treads. While 50-50 blends are more practical to process, mileage could be upped as much as 90 percent in pure cis-butadiene treads, says Goodyear.

About the process: Sulfur content is kept low to maintain tire cure. Extending is done with petroleum oil, and ISAF carbon black is used. Company will begin making both staining and non-staining types in 20,000-ton-per-year Beaumont plant.

Koppers and epoxy resins

A new line of epoxy resins have gone into commercial production by Koppers. They are made by reacting an ortho cresol-formaldehyde novolak with epichlorohydrin. Novolak's molecular weight determines resin's molecular weight (functional from 2.5 to 5.5). Koppers claims its resins permit more cross linking, high resistance, and



You get 20% MORE COVERAGE

with EAGLE-PICHER SUPER "66" insulating cement

for temperatures up to 1800 F.

Because Super "66" Insulating Cement gives you less shrinkage (volumetric shrinkage wet to dry only 18½%), you get up to 20% greater dry coverage (50-55 bd. ft. per 100-lb.), with uniform thickness for better protection and strength. Result: You save warehouse space, time and labor costs.

Eagle-Picher Super "66" Insulating Cement *sticks to hot or cold surfaces.* It contains a special rust inhibitor that actually *prevents corrosion.* In addition Super "66" is easy to apply . . . reclaimable when used to 1200 F . . . and offers one of the most effective thermal barriers known. Super "66" can be applied on irregular shapes and usually requires no reinforcing on applications up to 1½ inches thick.

Eagle-Picher produces a line of industrial insulations for all temperatures from below zero to over 2000 F. See our complete catalog in Sweet's Plant Engineering File or write for descriptive material.

Since 1843

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The Eagle-Picher Company • General Offices

Dept. PR-1061 • Cincinnati 1, Ohio

Member of National Insulation Manufacturers Association

better thermal stability. It also offers a more flexible formulator in modifying properties, and features shorter curing times, says company.

SynNatural seen as rubber prodigy

A breakthrough in rubber science now permits industry to make any kind of synthetic rubber needed, says George R. Vila, president, of United States Rubber. His comments: "We have entered a revolution in rubber and rubber-like materials . . . We have shaken ourselves free from the molecular designs of mother nature and the previously uncontrollable course of synthetic molecular structure. We can now build molecules exactly to the specifications we wish."

Recent research achievements: Ethylene-propylene rubber, a promising tire material because of low cost and excellent performance; synthetic balata, new material for golf ball covers; submarine cable and possibly electrical wiring; and a new method for making vinyl pyridine rubber compounds to improve wear of tires and possibly conveyor belts.

Ethylene-propylene rubber is highly versatile class of rubbers. It can be made extremely resistant to ozone cracking and weathering and has a generally well balanced set of physical properties. It has bounce of natural rubber, wear of general-purpose styrene-butadiene rubbers and the ozone resistance of butyl.

Synthetic balata's development is expected to free the rubber industry from dependence on natural balata latex. The natural product has become more difficult and expensive to obtain because each season workers must go farther into the jungle in search of trees.

U.S. Rubber scientists developed successful synthetic balata as an outgrowth of studies in stereo-regular polymerization that began in 1954. Substance is a moderately hard, tough, crystalline thermoplastic material, "trans 1,4 polyisoprene."

Man-made balata is completely equivalent to the natural material. Vinyl pyridine synthetic rubber is extremely resistant to abrasion and gives higher performance with the addition of certain inorganic chemicals. It will perform well in tire treads and conveyor belts, where abrasion resistance is an advantage in longer wear.

The summing up: Look for further research to develop polymers with the ultimate in resistance to heat, light, oxygen, ozone and high-energy radiation. Survival on other planets will require us to meet the demands of extreme temperature ranges, entirely new atmospheres and bombardment by cosmic radiation.

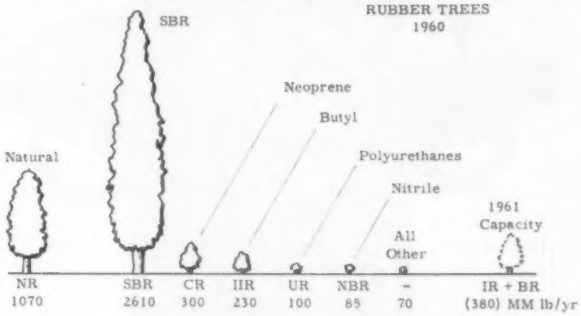
Good news for foam makers

Next five years should be good ones for foam industry, says new Du Pont report. The rundown: Both consumption and production will increase, and industry will expand markets in building, marine, insulation, electrical wiring, packaging, electric household refrigerator, commercial refrigerator, textile and carpet cushioning fields. Survey, which included studies of some 35 industries, says demand for foams in 1966 will be about 800 million pounds. Production will be some 740 million pounds, compared with 248 million this year.

The big picture in elastomers

Although seeds of many new "synthetic rubber trees" are germinating in labs all over the world, look for petroleum industry to keep supplying bulk of monomers from which these elastomers are made. Prediction was made by Dr. Harold Gershinowitz, president of Shell Development, at ACS national meeting.

The trend: Many chemical companies are now also making monomers and this will probably increase. The chemical sophistication of many processes described has not made them economically unrealistic. Even more



Elastomers in U.S. rubber production.

exotic olefins and diolefins will become readily available if large scale needs for them should develop. Entire pattern of elastomer consumption in U.S. has shifted from virtually exclusively *natural* to predominantly *synthetic.*

"There may have been a time when materials from which the chemical industry synthesized its products were 'raw'," says Dr. Gershinowitz, "but to so designate today's monomers would be an undeserved indignity. The end products of the chemical industry have much more glamor than its starting materials . . . Nevertheless a remarkable amount of outstanding chemical research has made possible commercial production of olefins needed by the chemical industry."

Fuel cells still in news

An agreement has been signed for exchange of research information and for future development of fuel cells by Sun Oil and Electric Storage Battery Co. Sun has been doing research on fuel-cell catalyst system, while Electric Storage Battery's specialty is fuel-cell electrodes. Although there may be many uses for fuel cells in future, biggest present potential is in portable applications with moderate electrical requirements.

UOP offers new secondary amines

UOP is making development quantities of a new series of secondary amines—N-(1-methylheptyl)-ethanolamine, N,N′-bis (1-methylheptyl)-ethylendiamine, N-sec.-butylanaline, Bis (1-ethyl-3-methylpentyl) amine and N, N′-bis (1-ethyl-3-Methylpentyl) diethylene triamine. These versatile amines have broad potential applications. As organic intermediates, they can be used for preparation of unique amides, esters, fatty acid soaps, fungicides, bactericides, surface active agents rubber chemicals, pharmaceuticals and many other such products. Company also claims they may also find application as cationic flotation agents, curing agents for epoxide resins, cross linking agents for

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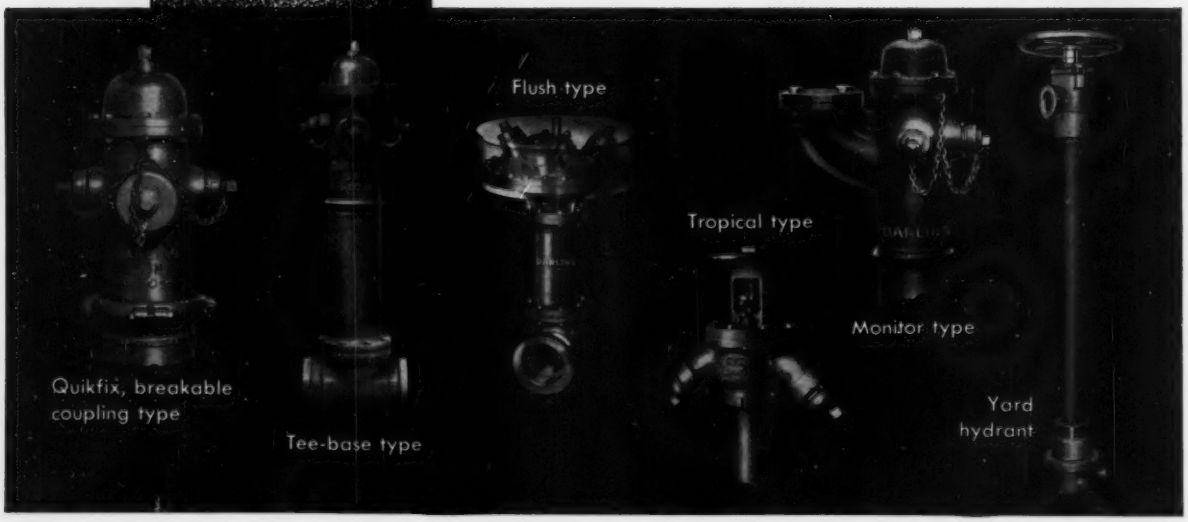


polyurethane foams, dispersants, emulsifiers and solubilizing agents.

Predicts record for '62 chemical sales

Chemical industry sales will reach a record high of more than $30 billion dollars next year, says Chris F. Bingham, vice president, chemical sales, chemical division of Pittsburgh Plate Glass. In an address before the National Industrial Conference Board, he said chemical industry sales for 1960 were $27.7 billion and that sales estimates for this year exceed $29 billion. He forecast that sales during 1962 would increase at the rate of 3 percent to 6 percent to move the industry past the $30-billion mark.

Helium: Sky is limit

Up, up, up goes helium demand for defense and industrial uses. It has jumped from 80 MMcf in 1950 to more than 520 MMcf in 1960. Latest big development on helium scene is government's new purchase contracts with helium-recovery companies, 12 of which are planned. Already on bandwagon are Cities Service Helex, a subsidiary of Cities Service, and Helex Co., which is owned by Northern Natural Gas. In the mill: Contracts for Helium Conservation Corp., and Panhandle Eastern Pipe Line.

LPG, ethane on the way up

LPG and ethane are still finding big home in U.S. chemical industry, to tune of 19.5 percent increase in 1960 over 1959. Commercial and domestic uses gobbled up the biggest chunk, 4.22 billion gallons, while chemical consumers accounted for 3.02 billion gallons. Five-year projection of LPG as chemical feedstock reveals a fantastic 88.6-percent increase. Refinery fuel and synthetic rubber were other uses where gains were made in 1960.

Enjay moves into ethylene-propylene

Ethylene-propylene rubber is on the move at Enjay Chemical, as company begins marketing product in development quantities at Baton Rouge. AviSun has been in EPR business for over a year on volume basis, and Hercules and Du Pont are said to be interested.

Points of interest: Esso-Engineering-developed Enjay product features better vulcanizing agents to cure elastomer. Previous method involved sulfur and organic peroxides, such as dicumyl peroxide. But Esso technique employs trichloromelamine, quinone-N-chlorimide, and trichloromethane sulfonyl chloride to eliminate old method's poor hot-tear strength, bad odor, costliness. Enjay product features tear strength close to 300-pounds-per-inch.

ECONOMICS

Plants close in wake of Carla

Petrochemical facilities and refineries along Texas Gulf Coast were at standstill in early September when Hurricane Carla battered coastline. Most plants suffered no serious damage. As dike broke near Freeport, Dow Chemical's big chemical complex caught 4 to 14 feet of rain and sea water. Other plants most directly in Carla's path were Du Pont's Victoria, Texas, facilities, and Union Carbide at Seadrift. United Carbon's carbon black unit at Aransas Pass, similarly in hurricane's wake, sustained only minor damage.

At Texas City, Monsanto and Carbide had only slight wind and water destruction. Much debris littered American Oil's Texas City plant after storm, but major damage there was loaded crude oil barge that sank at refinery's docks. Humble Oil & Refining's 40-million-pound polypropylene facility at Baytown received slight damage. Cat cracker was also damaged. Other plants that had light damage were Olin Mathieson, U. S. Industrial Chemicals and Ethyl.

Grammar for computers

Newly constructed recognition grammar is being used to directly translate chemical names into molecular formulas by Institute for Scientific Information, Philadelphia. Grammar is stored on magnetic tape for use in computer. How it works: Name is typed out and within five seconds machine spits out formula. Next step, expected by ISI within two years, is using computer to convert chemical names directly into structural formulas.

A look at engineers and unions

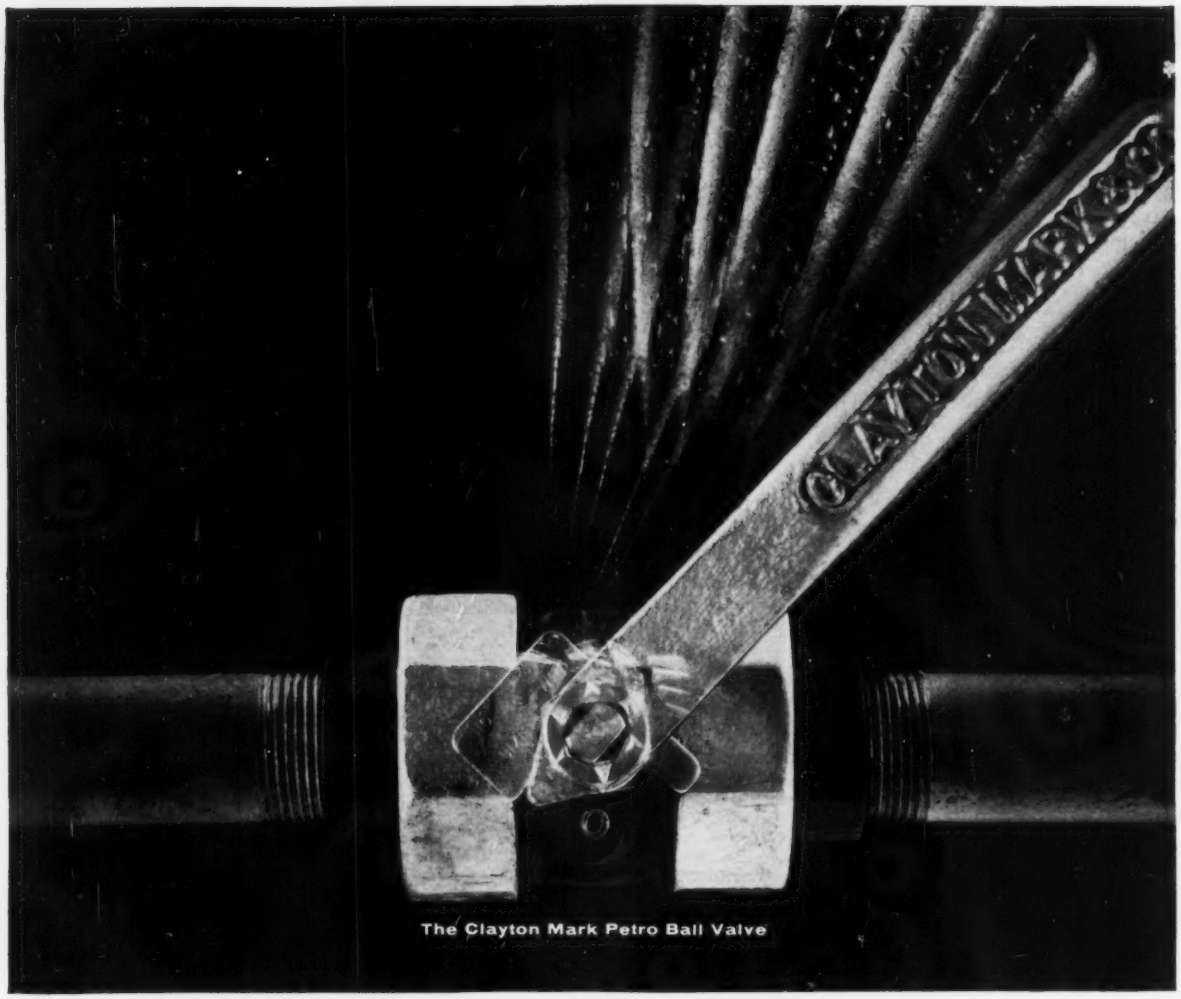
What is minimum gauge of "professional" status for collective bargaining purposes? According to new book published by NSPE, it's the bachelor's degree. *"The Engineer in the 1960's"* says that in recent years a growing number of decisions by National Labor Relations Board have involved engineers' educational background as criteria to determine collective bargaining voting units. Says the book: "Perhaps this is an indication of the increasing national trend to require college graduation as prerequisite for recognized professional status."

What is the professional engineering union's impact? According to Purdue University's Professor R. E. Walton, in his new book, *"The Impact of the Professional Engineering Union,"* studies of 11 large companies with engineering unions, engineers find union representation an uncomfortable solution to their problems. Further, engineers tend to resist many traditional union tactics.

Other points: Unions strengthen merit raise provisions, but because of negotiated salary increases, merit-raise provisions apply to a smaller area. Union strikes, demonstrations and publications damage company's engineering reputation—hurting recruiting and contact-getting programs. Finally, union's portrayal of management as untrustworthy creates serious disputes among engineers over issues that would not ordinarily be of concern.

NSPE urges government, society harmony

The National Society of Professional Engineers has urged a Presidential task force studying employe-management relations in government to provide equal opportunities for all organizations to meet with agency officials and offer suggestions on federal personnel policies. Paul



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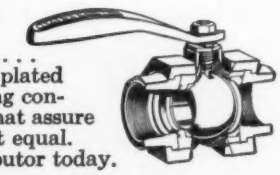

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H. Robbins, NSPE executive director, says the special interests of professional employes require that they have right to express their views and opinions through their professional association. An association is better equipped and more responsive to their needs than are organizations composed of mixed groupings of both professional and non-professional personnel. "We would view with disfavor any procedure or language which could be read so as to confine such rights to labor organizations or unions," he added.

Tanks, fuels systems being 'bugged'

Heavy accumulation of bacteria in storage tanks and fuel systems may create unusual damages, expense and hazard, according to a new Midwest Research Institute study. Firm analyzed growth of fungi, yeasts and bacteria, in kerosene, diesel fuel, jet fuel and fuel oils.

What they found: High bacterial counts often develop in storage tanks, and these substances within aircraft fuel systems could deter efficient operations. Petroleum companies have been concerned with prospects of bacteria corrosion in metal tanks. Also, quality and color of certain fuels may be affected, odors may be produced, and some types of fuel additives are consumed by organisms.

Gasoline is not affected much by infiltration of bacteria. Kerosine and jet fuels seem unusually susceptible. The organisms can spread from one tank, or fuel system, to another in normal process of fuel transportation.

INTERNATIONAL

Japan's petrochemicals future bright

Japan paints bright future for petrochemicals, with more than 20 percent growth per year through 1970. Forecast just released by Japanese trade agency, MITI, says largest expansion will be concentrated on polypropylene. Japan expects an annual market growth for this polyolefin to exceed 30 percent. How other plastics are expected to grow: Vinyl chloride to triple between 1961-70; phenolics up five times in same period, urea-formaldehydes to double; melamines to increase more than four times.

Feed stocks for these materials will also be in for big boosts. For example, caprolactam should triple current output and acrylonitrile jump about five times present production. Terephthalic acid and polyvinyl alcohol should expand by a factor of five.

Entire petrochemical production industry is set for large expansion plans. Of course, current domestic production will take some of this added capacity, but exports will be a prime target, which could affect overall world markets.

Octane ratings up from year ago

Average octane number ratings for regular summer-grade gasolines, sampled in 15 marketing areas throughout country, showed slight increase from year ago. So says Du Pont's semi-annual survey of road octane ratings. Road octane numbers of regular-grade gasolines for the summer 1961 averaged 91.4 and motor octane, 84.3, both up .1 from mid-1960. Research octane was 92.5, a gain of .3 point. Sensitivity (difference between research and motor numbers) increased by .2 point.

In premium-grade gasolines, average road octane numbers stood at 98.6, an increase of .1 point compared with summer 1960. Motor octane advanced to 90.0 for .7 gain, and research was 99.4, a gain of .2 point, giving a sensitivity decrease of .5 point. Average octane numbers for higher premium grade were above 1960 summer survey averages by .3 road, .5 motor, and .1 research. Sensitivity decreased .4 octane number. Figures for road octane were 101.1, research, 101.8, and motor, 92.9.

In recognition of the trend toward the use of different types of lead alkyl antiknock compounds, the Du Pont survey for the first time shows the lead content of gasolines expressed both as grams of metallic lead per gallon, and as milliliters of TEL per gallon.

Average TEL content of regular gasoline was 1.85 ml. per gallon, an increase of .04 ml. compared with year ago. For premium gasoline, figure was 2.49 ml. per gallon, up .04 ml., and for higher premium, 2.48 ml. per gallon, a decrease of .24 ml. On the basis of grams of metallic lead per gallon, comparable figures for summer 1961 are: regular grade, 1.96 grams of Pb per gallon; premium, 2.63 grams; and higher premium, 2.62 grams.

Mono-olefins: U.S.S.R.

Mono-olefins are being boosted by Soviets in their research for better petrochemical industry. Increased research in use of LPG—propane and butane—for production of ethylene, propylene and butadiene, is evident from lab to production plant. Soviets claim to have process for acrylonitrile from propylene and ammonia which would be superior to present acetylene-HCN route. This research effort, aimed at synthetic fibers and elastomers, points up lack of natural products to fill these important needs.

Soviets appear to be seeking elaborate synthetic fiber production schemes. They have reportedly developed a process for acetaldehyde from ethylene similar to the Aldehyd GmbH process which Celanese will install at Bay City, Texas.

Synthetic rubber in the Soviet countries must be compatible with present natural rubber processing equipment. Therefore, their developments will concentrate in the syn-natural field. Watch for intensive research in the polyisoprene and polybutadiene fields as these elastomers more nearly duplicate natural tree rubber.

for more about what's happening in HPI, turn to Page 271

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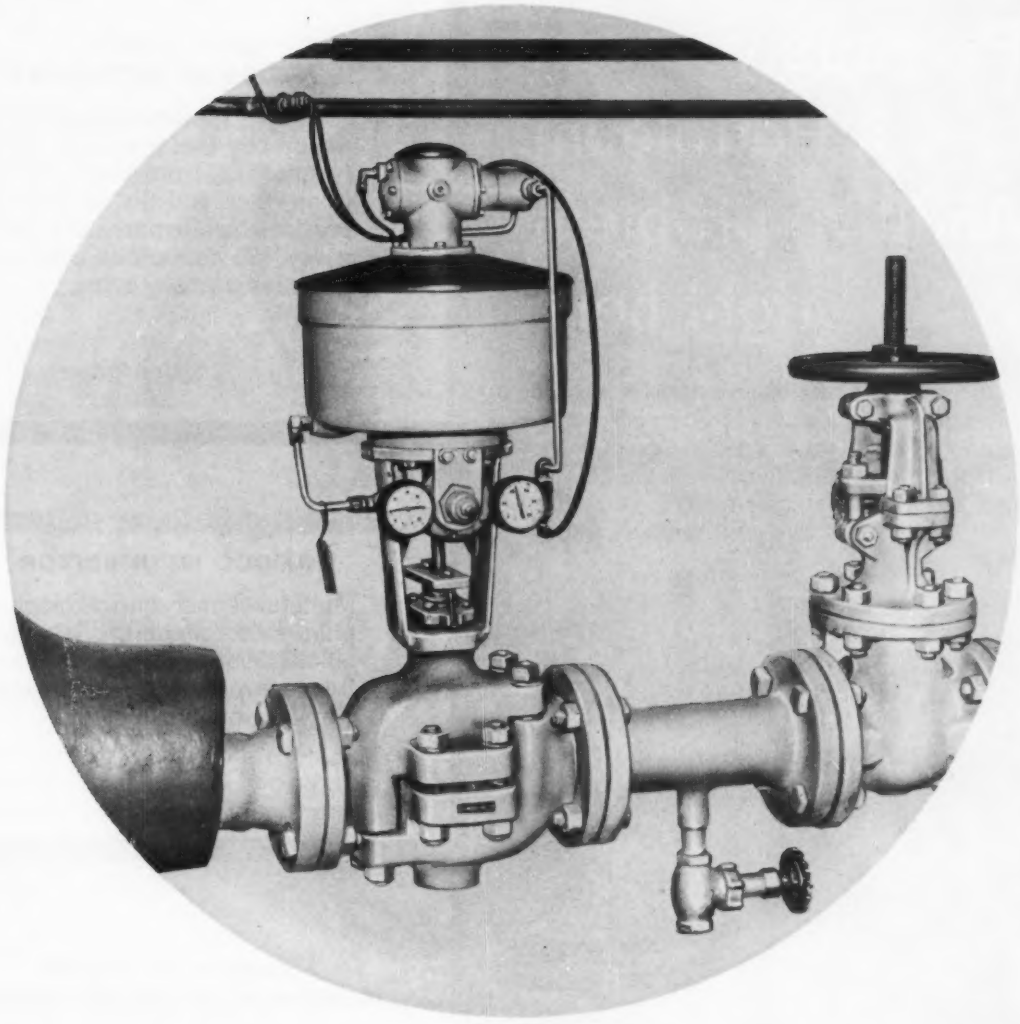

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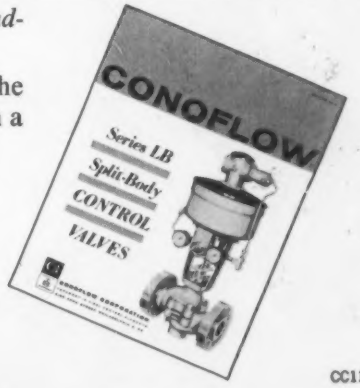

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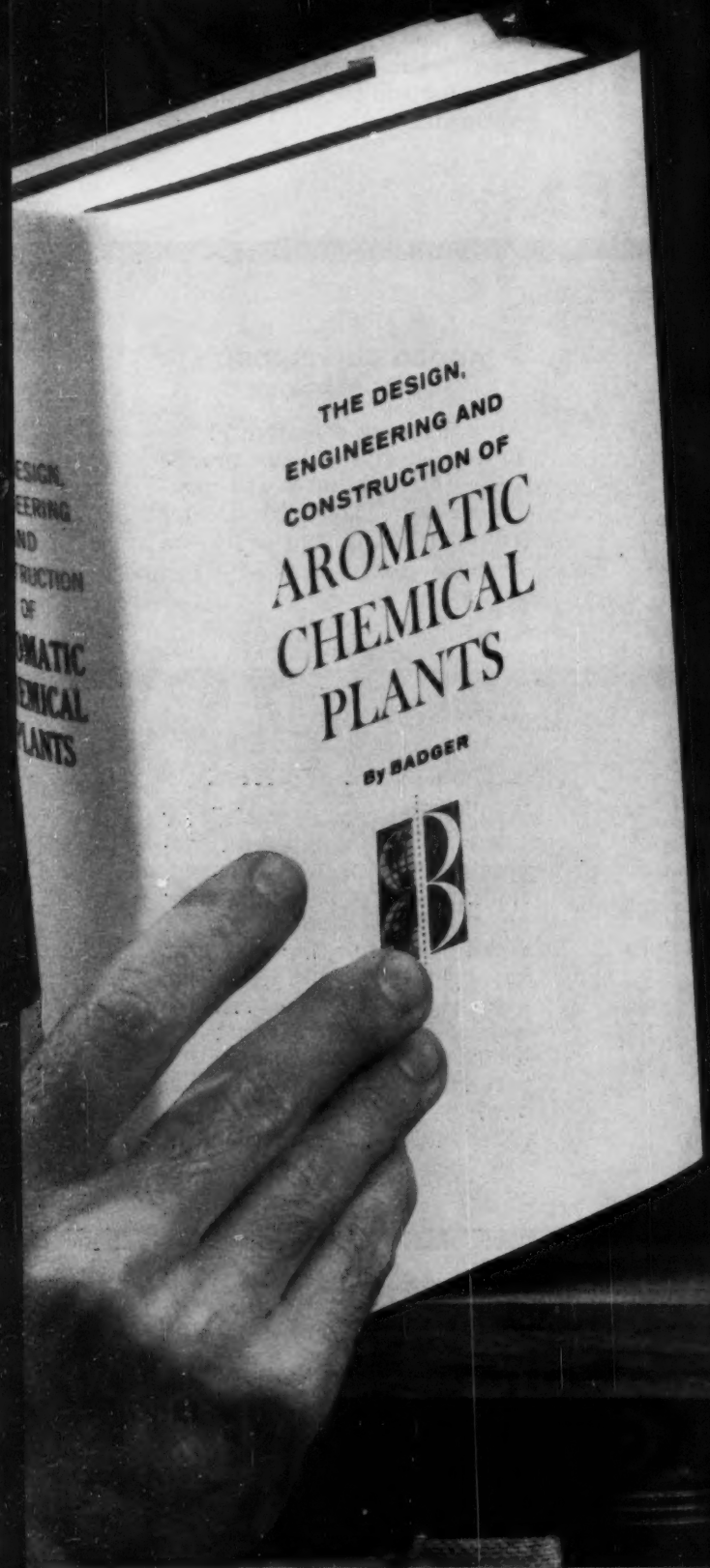

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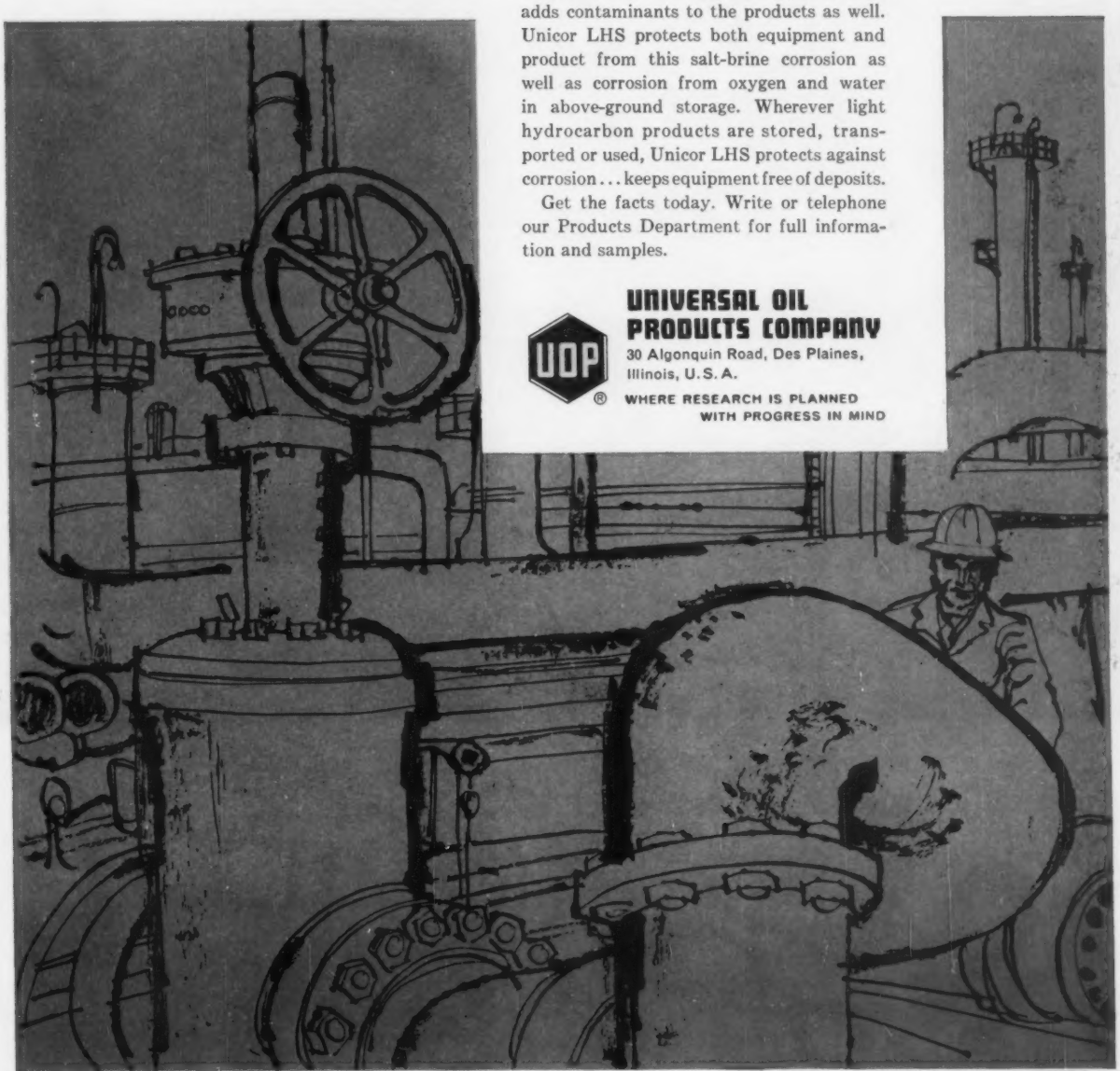

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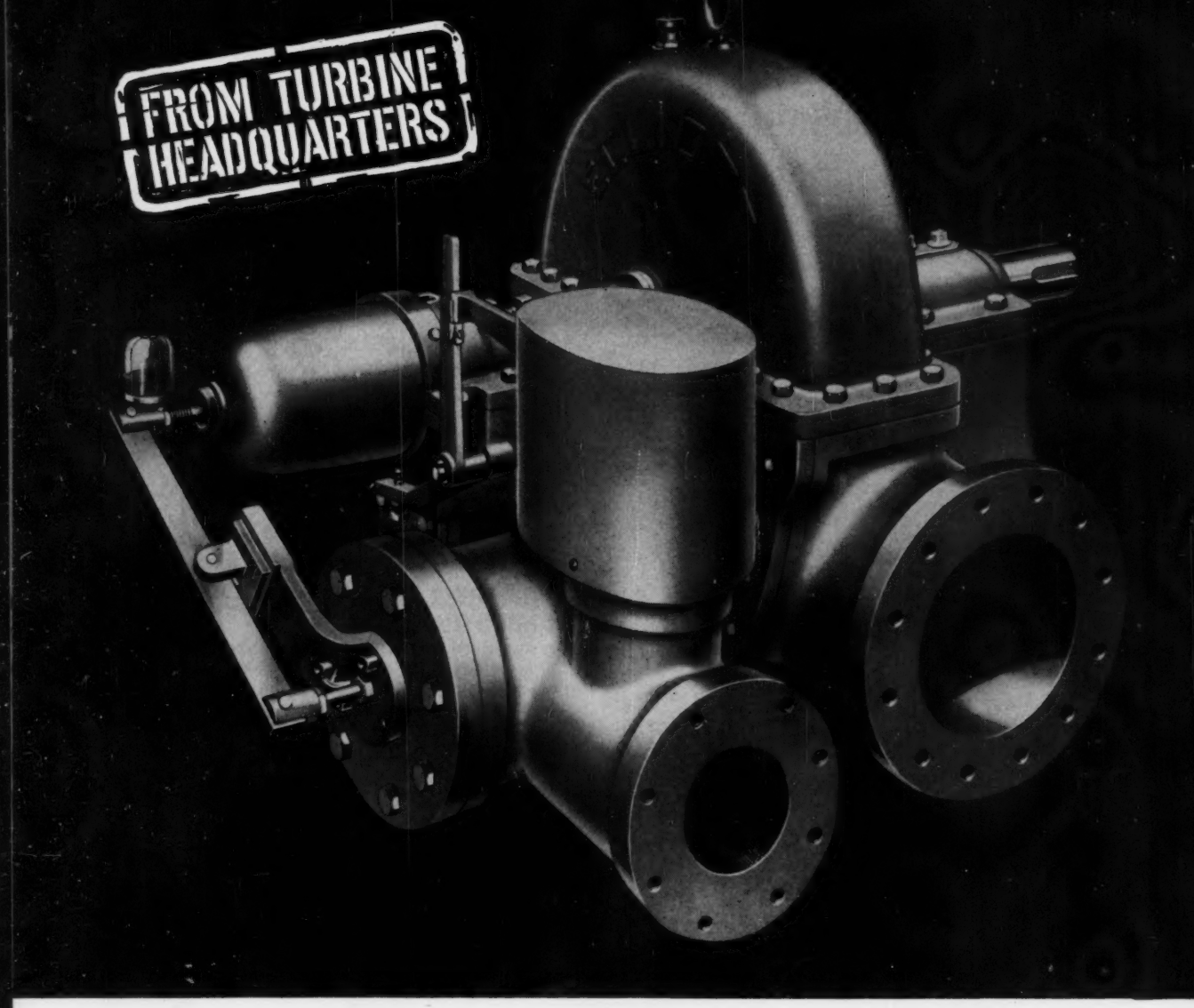

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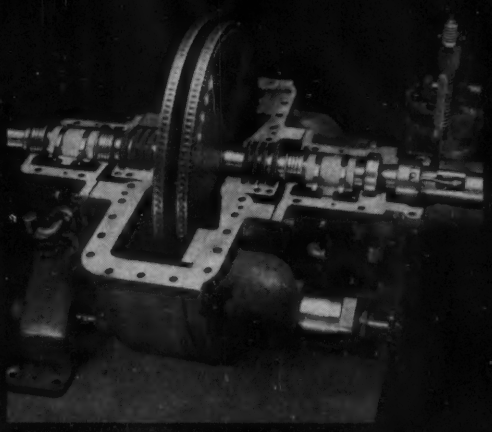

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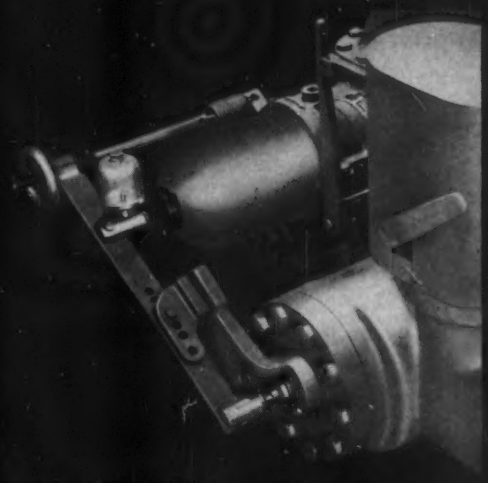

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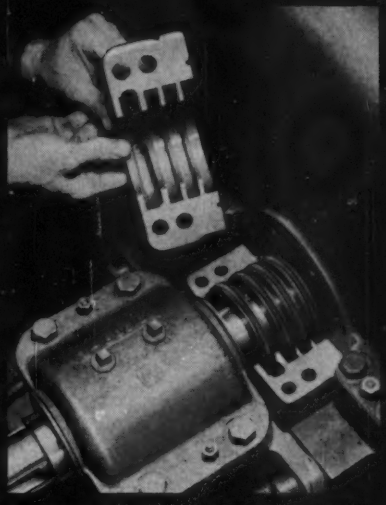
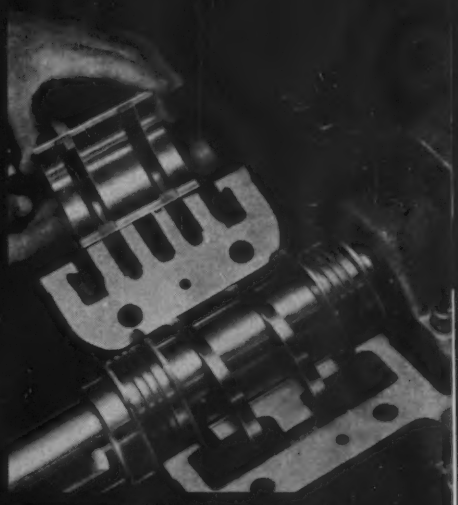
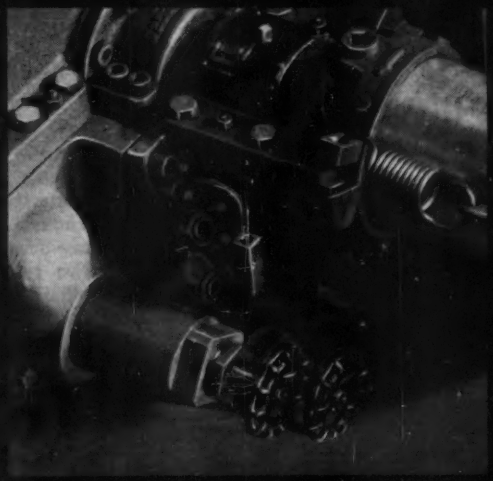
5. Optional hand valve
6. Full protection



Accessible shaft-seals simplify maintenance and routine inspection. Covers readily removed without disturbing casing.



Inexpensive liner-type bearings readily installed with no scraping, fitting or adjustment required.



Steam-saving hand valve with pilot, which can be opened against full steam pressure, reduces steam consumption at partial loads.

All-weather protection is standard for Elliott YR turbines. They shrug off heat, snow, moisture, dust or contaminated atmosphere.

Six marked differences make Elliott turbines a better buy

Why are Elliott YR turbines your best choice for mechanical drives? Some of the reasons are described on the opposite page. These are tangible reasons why you can expect dependable, economical operation with little care or attention.

With more than 50 years' experience in mechanical-drive turbines up to 50,000 hp; with the most complete line of field-proven machines; with engineering and service facilities nationwide: Elliott is clearly "Turbine Headquarters." Write for bulletin H22-D.

TURBINES FOR DEPENDABLE day-in/day-out SERVICE

H1-1

ELLIOTT COMPANY

GENERAL OFFICES: JEANNETTE, PENNSYLVANIA
PLANTS AT: Jeannette and Ridgway, Pa.; Springfield, Ohio
TURBINES • GENERATORS • MOTORS • COMPRESSORS
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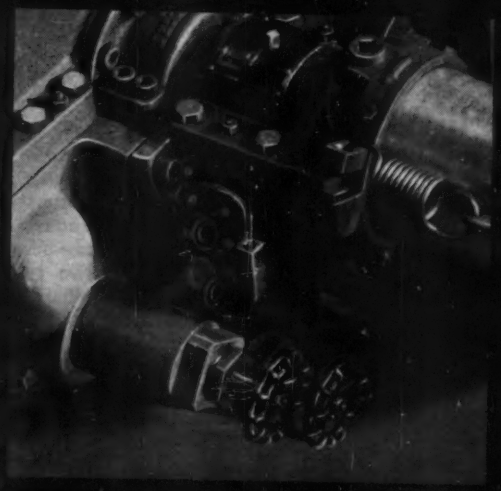
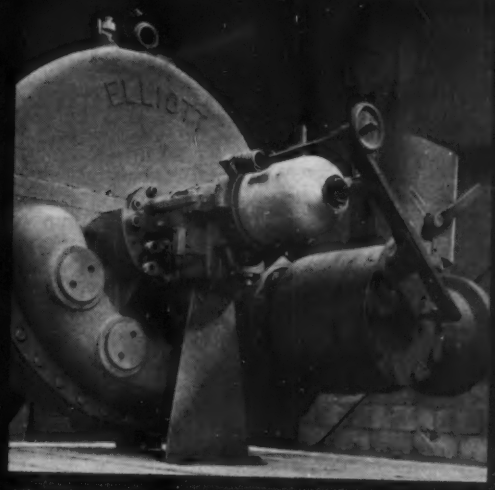
Accessible shaft-seals simplify maintenance and routine inspection. Covers readily removed without disturbing casing.

Inexpensive liner-type bearings readily installed with no scraping, fitting or adjustment required.



Steam-saving hand valve with pilot, which can be opened against full steam pressure, reduces steam consumption at partial loads.



All-weather protection is standard for Elliott YR turbines. They shrug off heat, snow, moisture, dust or contaminated atmosphere.

Read how this low clearance 7-ton crane eliminates A-frames and staging erection . . .

It is an Austin-Western hydraulic crane —highly mobile, self-propelled. Available in five models with capacity ranges from 5 to 11 tons. Low clearance (11 ft. 1 in. on biggest model) lets you move in fast for repair and maintenance and without dismantling overhead pipes for crane passage.

Optional personnel platform attachment carries men aloft—no staging to erect. An A-W can thread its telescoping boom into the most impossible places for safe lifts with speed and precision. Boom rotates in continuous full circle; hydraulically retracts and extends to lengths up to 48 feet on some models.

Inefficient A-frames are obsolete. The A-W cranes, equipped with all-wheel drive and steering, are so maneuverable they can operate efficiently in quarters too tight for other lifting units to enter.

This is top-quality equipment—dependable to operate, inexpensive to maintain. Ask your nearest A-W distributor for more information and the names of refinery owners of A-W cranes —or write us here in Aurora.

Austin-Western CONSTRUCTION EQUIPMENT DIVISION, AURORA, ILL.

BALDWIN · LIMA · HAMILTON

BALDWIN BLH LIMA-HAMILTON

Heating season ahead

Time to stabilize and improve your heating oils with FOA-2

No filter clogging. No nozzle plugging. No sludge.

These are qualities you can add to your heating oils, and at low cost, too. Result: a clean, hot, steady-burning fuel that wins added friends for your brand product.

You need only a few pounds of Du Pont Fuel Oil Additive No. 2—usually 5 to 15 pounds per 1,000 barrels—to do the job. This concentration has stabilized millions of barrels of heating and fuel oils since the introduction of Du Pont FOA-2 nine years ago.

FOA-2 solubilizes and disperses. Prevents sludge formation. Dissolves sludge which may already have formed. Reduces insoluble residue to such small particles that they flow and burn right along with the oil. *It stabilizes your product.*

Of course, FOA-2 is ashless—burns completely with the fuel, leaves no traces to foul the burner nozzle.

28 pages of facts. Our 28-page bulletin, "Du Pont FOA-2 for Diesel, Heating, Residual Fuels," contains full details on chemical, physical and performance characteristics. Ask your Du Pont Petroleum Chemicals representative for a copy, or write: E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

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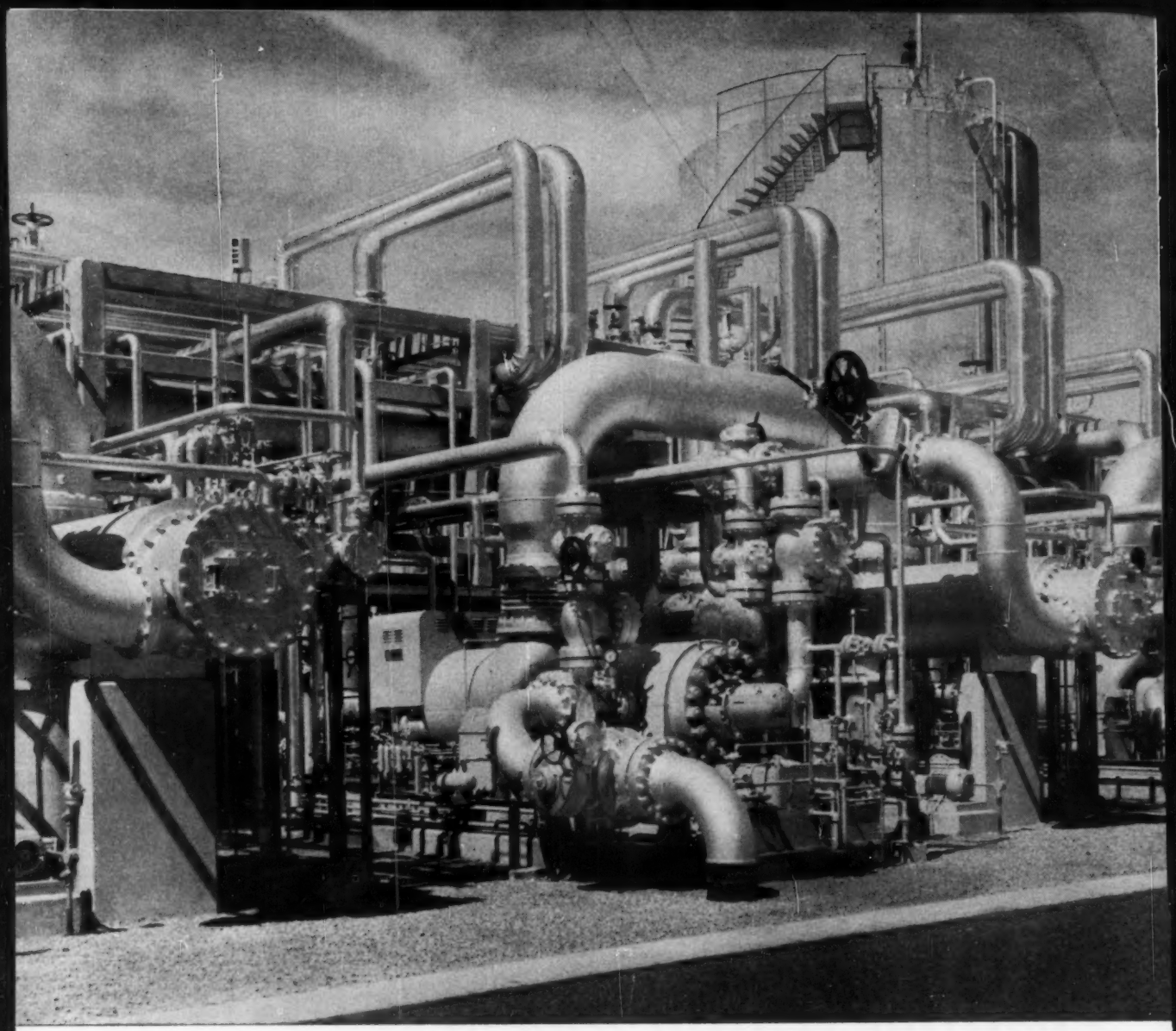
. . . through Chemistry

Lead Antiknock Compounds *and other* PETROLEUM ADDITIVES

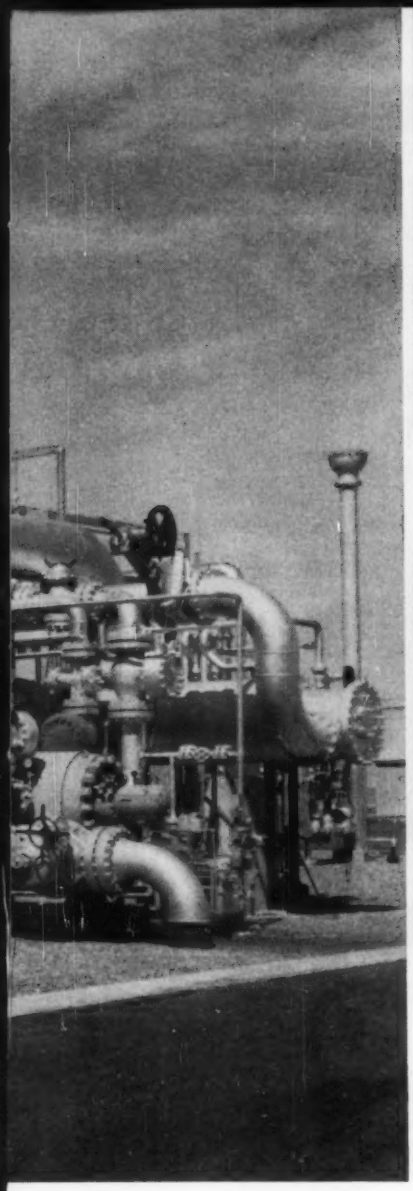


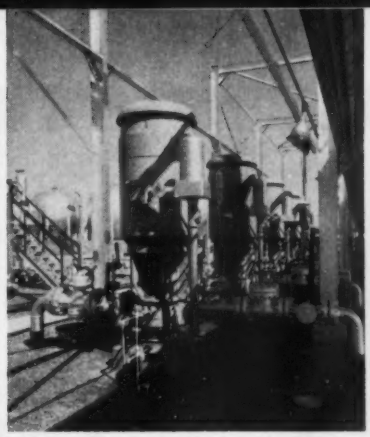
AT HUMBLE'S KING RANCH GAS

These pumps have a combined capacity of 139,000 gpm — -

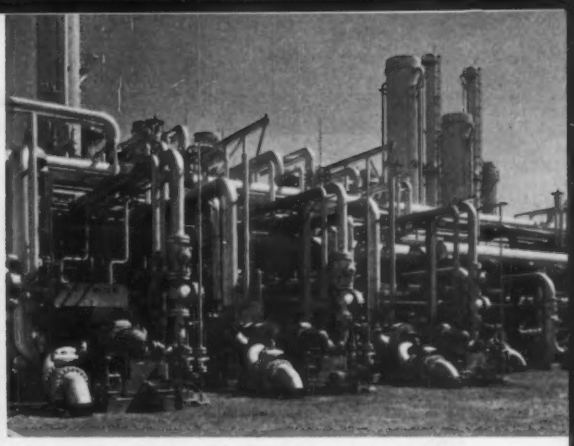
This new plant also contains five Ingersoll-Rand air compressors and two Ingersoll-Rand steam-jet ejectors for vacuum service.

Whatever *you* need in the process-pump line is available from Ingersoll-Rand, manufacturer of the world's *most complete line* of centrifugal pumps.

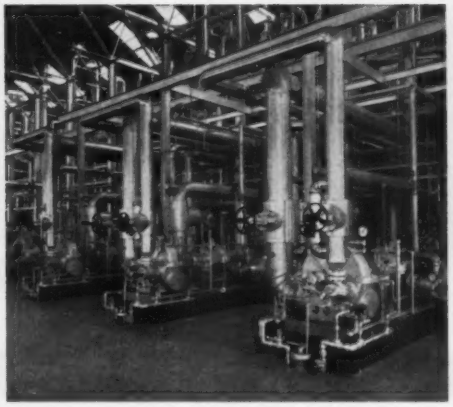




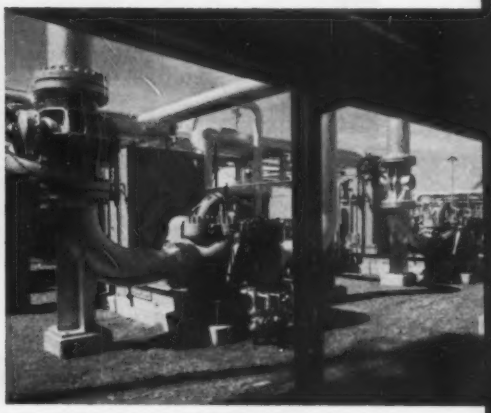
Five Ingersoll-Rand VHTB multi-stage vertical pumps for handling propane and butane at shipping terminal for distribution to product pipelines.



Three Ingersoll-Rand HMTA four-stage pumps specially designed with one interstage bleed-off connection to combine two lean absorption oil services for pressure levels of 480 and 1000 psig.



Three of four Ingersoll-Rand CNTA eight-stage boiler-feed pumps operating at a discharge pressure of 750 psig.



Two Ingersoll-Rand BHV hydraulic turbines designed to recover power from the high and low pressure rich oil stream to drive a 1500 hp and 1000 hp induction generator.

Two of three Ingersoll-Rand CHTA six-stage, barrel-type pumps specially designed with two interstage bleed-off connections. Three lean absorption oil services are combined in one pump for pressure levels of 1000, 1270 and 1880 psig.

PLANT there are 104 IR centrifugal pumps in various services.

a total of 20,000 horsepower.

Ingersoll-Rand®

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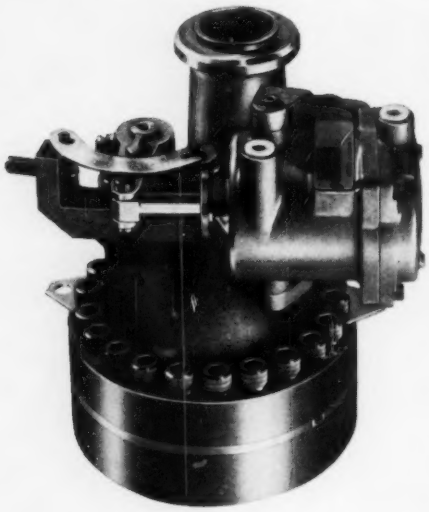
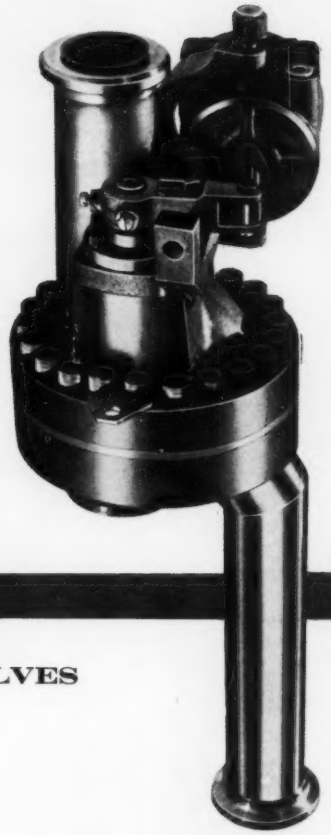
MORE THAN A CENTURY OF PUMP PROGRESS

IR®

FOR HIGH-TEMPERATURE, HIGH-PRESSURE APPLICATION...





NEW 2 AND 3-WAY CECO VALVES ARE READILY ADAPTABLE TO YOUR REQUIREMENTS!

Fabricated without organic materials, the carbon steel valves pictured here represent a new Chandler Evans valve design which lends itself to a variety of special-purpose applications.

Requirements on this particular assignment were for valves to provide flow of demineralized water up to 400 gpm at temperatures to 600°F. and pressures to 2000 psig, with minimum maintenance for 25-year service. An air-operated actuator is an integral part of each assembly, and an air-supply system and remote control panel complete the package.

Development of valves in this series was facilitated by CECO's high-temperature test loop. CECO engineers accented flexibility in design. The valves can be scaled up or down to suit other flow, temperature or pressure requirements. They can be fabricated from materials compatible with corrosive fluids. They are ideal for remote control installation, using manually or electrically operated selector valves. Pneumatically actuated in present form, they can be adapted for mechanical, hydraulic or electrical actuation.

To discuss your requirements, contact Mr. Harold E. Francis, Nuclear and Industrial Products Manager.

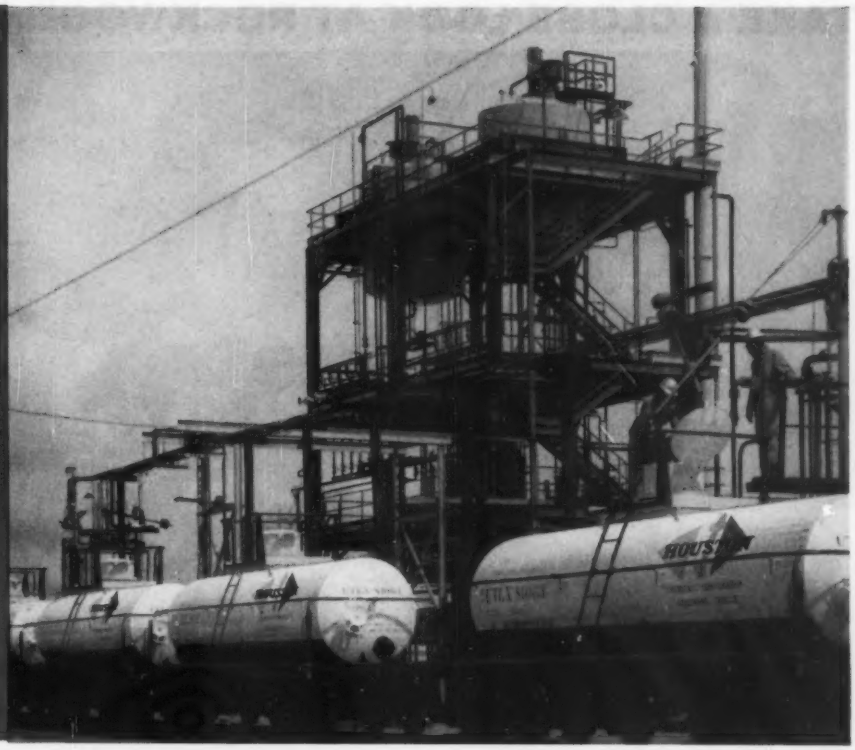
CHANDLER EVANS CORPORATION West Hartford 1, Connecticut

A SUBSIDIARY OF FAIRBANKS WHITNEY CORP.

CECO SYSTEMS CONTROLS

THE NEWS FROM TEXAS IS BIG

(naturally!)



news! The first shipment of TEL from Houston's new Beaumont, Texas, plant has **already been made.** The plant is on stream well ahead of schedule. And well below cost estimates.

news! The originally estimated capacity of 60,000,000 pounds per year has been beefed up to 100,000,000 pounds.

news! The oil refining industry now has a third, and important source of supply for lead anti-knock additives. Your inquiries are invited.

HOUSTON

HOUSTON CHEMICAL CORPORATION

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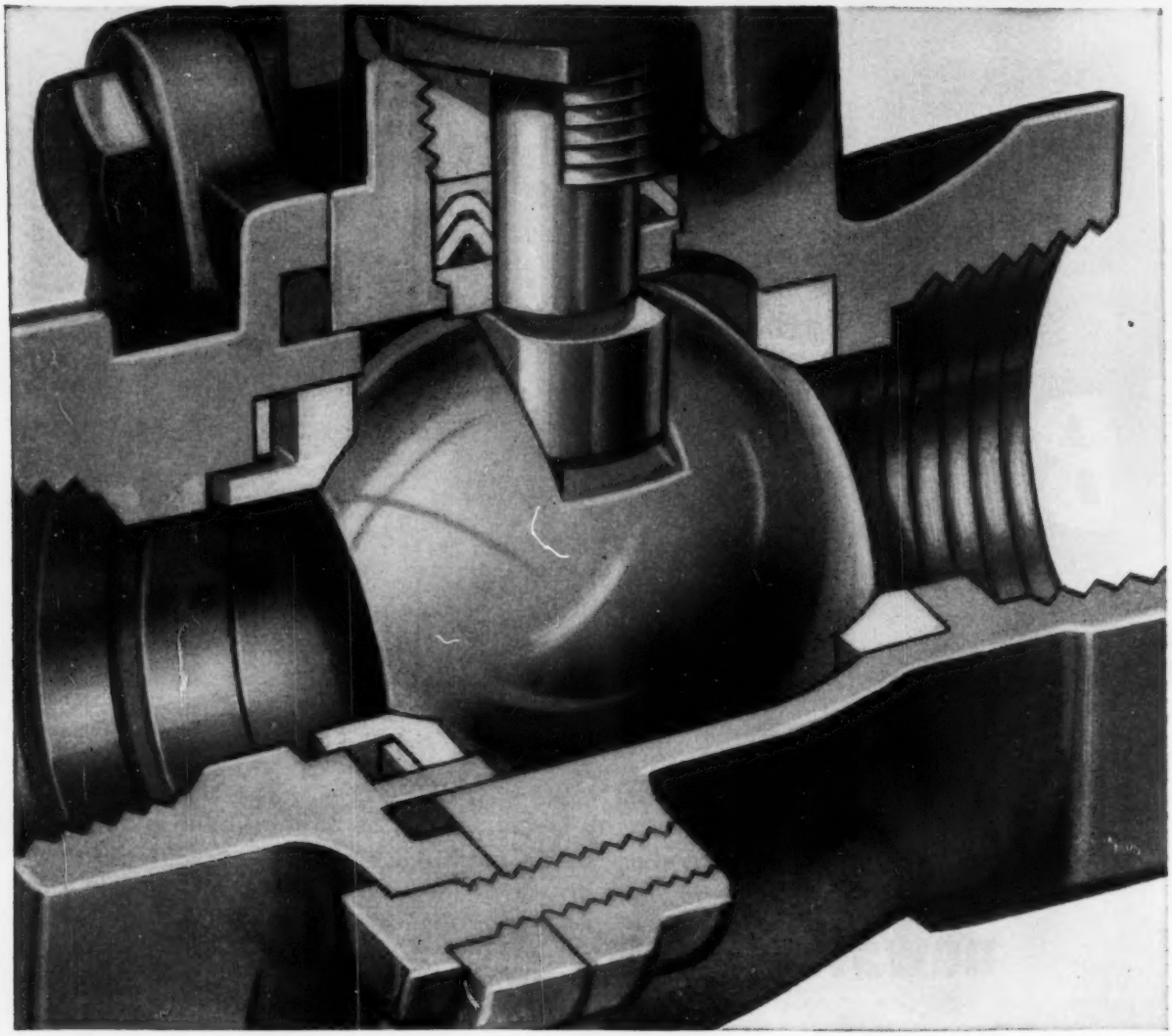
PRODUCERS OF

Alkyl Lead Compounds: Tetraethyl Lead • Tetramethyl Lead
TEL-TML mixes (unreacted) • TEL-TML mixes (reacted)
Ethylene Oxide and Ethylene Glycols: Anti-freeze Grade Glycol
Anti-freeze (formulated) • Diethylene Glycol • Industrial Grade Glycol • Triethylene Glycol
Sulfuric Acid **Oleums** (all strengths)
Bromine Compounds: Ethylene Dibromide • Bromine (elemental)

For more data on advertised products, use cards, last page.

TAKE A CLOSE LOOK AT ROCKWOOD BALL VALVES



How important is "choice"?

Few valve installations have identical characteristics. That's why you should look into the wide choice available in Rockwood Ball Valves. Rockwood Valves offer all these characteristics in various combinations: Castings of stainless and carbon steel, or bronze . . . flanged, sweat or screw ends . . . rubber, Teflon, nylon or Kel-F *ball seats* . . . lever, gear, air, electric or hydraulic *operation* . . . *pipe sizes* from ⅜" to 14".

When you call in a Rockwood man, you're sure to get the valve *you need* — not just the valve *he has* to sell.

And Rockwood Ball Valves have these important advantages:

Larger waterway diameters for smoother flow.

Ease of maintenance — no lubrication is needed; most parts replaceable with ordinary tools.

Spring-loaded ball seats for longer, tighter sealing.

Reliability — backed by the time-proven experience of the pioneer in modern ball valve design.

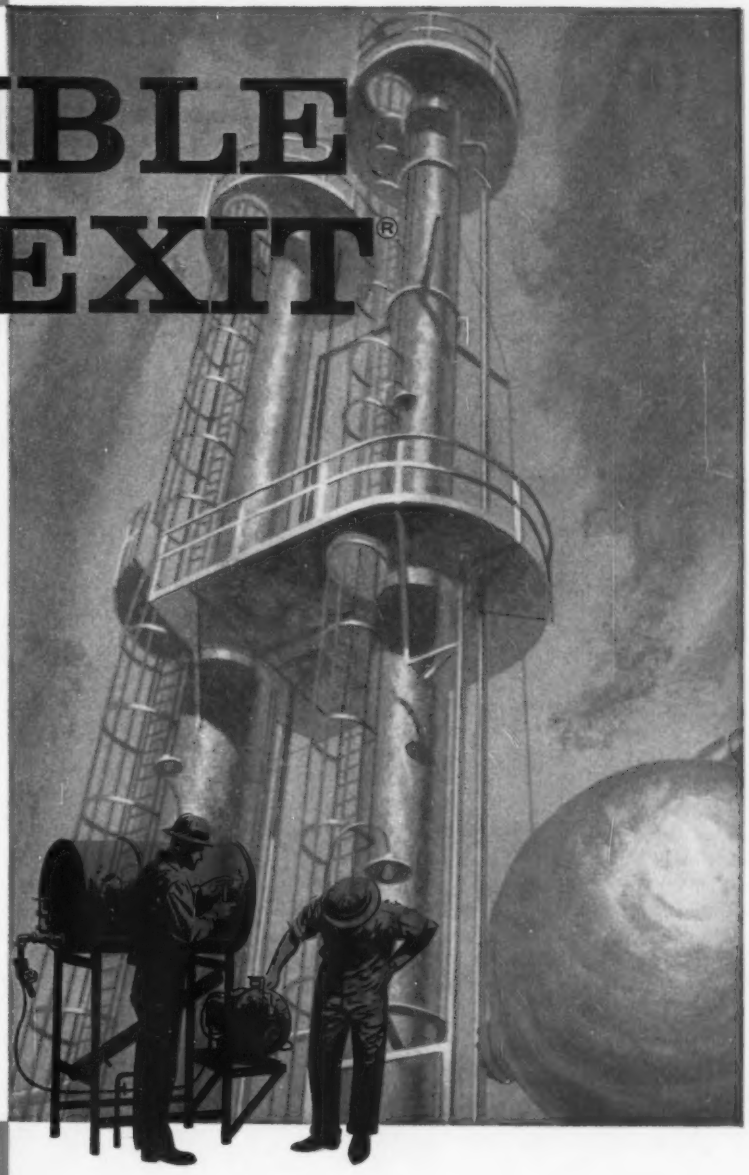
Your Rockwood man can provide full details, or write Rockwood Sprinkler Company, Ball Valve Department, 256 Harlow Street, Worcester 5, Mass. Distributors in all principal industrial areas. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E. W. Bliss Company.

ROCKWOOD

BALL VALVES

98% protection* against internal corrosion

HUMBLE COREXIT®



* *Ten years of measurements* in refineries and gas plants prove its high efficiency and economy. For as little as 50¢ per thousand barrels of throughput, Humble COREXIT prevents internal corrosion in pipe still overhead, distillation towers, vapor recovery systems and other refining units. Equipment life is extended, you make longer runs between turn-arounds, and down time is reduced. *COREXIT makes important savings in every refinery and gas plant where it is used.* For complete information on technical services and COREXIT formulations to meet your specific requirements, see your Humble salesman or contact Humble Oil & Refining Company, Houston, Texas.

ENCO PRODUCTS

HUMBLE OIL & REFINING CO.

America's Leading ENergy COmpany

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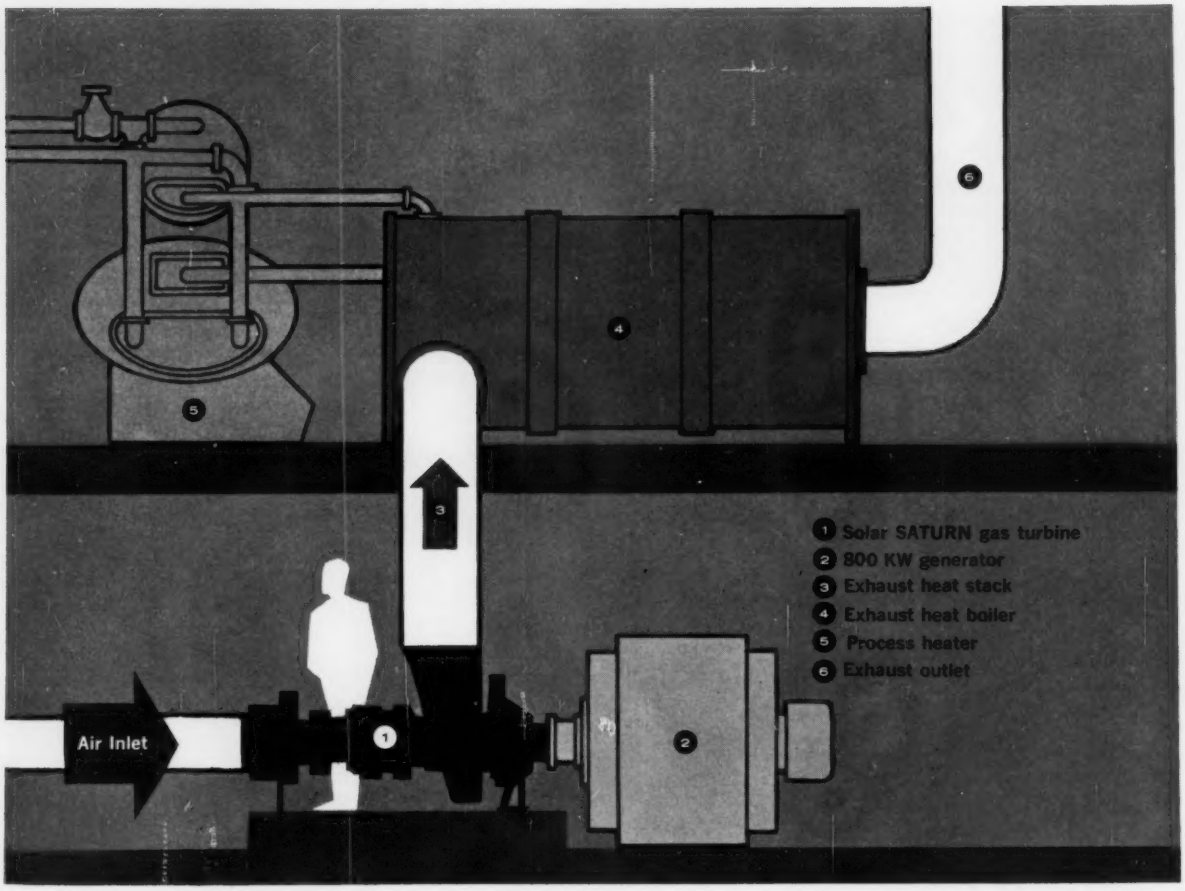
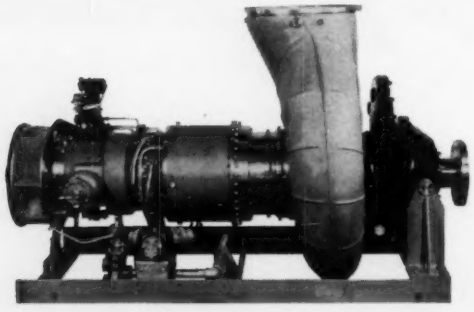


Solar gas turbine exhaust heat multiplies thermal efficiency

This unique system of efficient exhaust energy utilization illustrates one of the many advantages of Solar gas turbines. In addition to the turbine's main shaft power, exhaust gases can be put to work to multiply the thermal efficiency of the installation up to three times that of the prime mover alone.

In the typical system illustrated above, Solar *Saturn* gas turbines turn 800 kw generators, providing electricity for lighting and machinery. Turbine exhaust heat is passed through a boiler to provide steam for process or building heat.

This installation with three *Saturn* engines produces 2400 kw of electrical energy and 16,150 lbs of steam per hour. The complete package fits in a 60 ft by 40 ft space. The turbines will run on gasoline, kerosene, diesel fuel and natural or manufactured gas.



Exhaust heat utilization systems are easily adaptable to any job where electric power generation is needed, such as manufacturing and processing plants.

Solar gas turbines with their light weight, compactness, lack of vibration, long life and instant start capabilities are ideally suited for such jobs as electrical power generation, pumping, field and pipeline compression, oil well servicing, vehicle or marine propulsion.

Solar's family of gas turbines, from 50 to 1100 hp, are designed specifically for industrial use. Their design and manufacture are the result of over 15 years of experience. For further information, write to Dept. J-157, Solar Aircraft Company, San Diego 12, California.

SOLAR

A subsidiary of International Harvester Company

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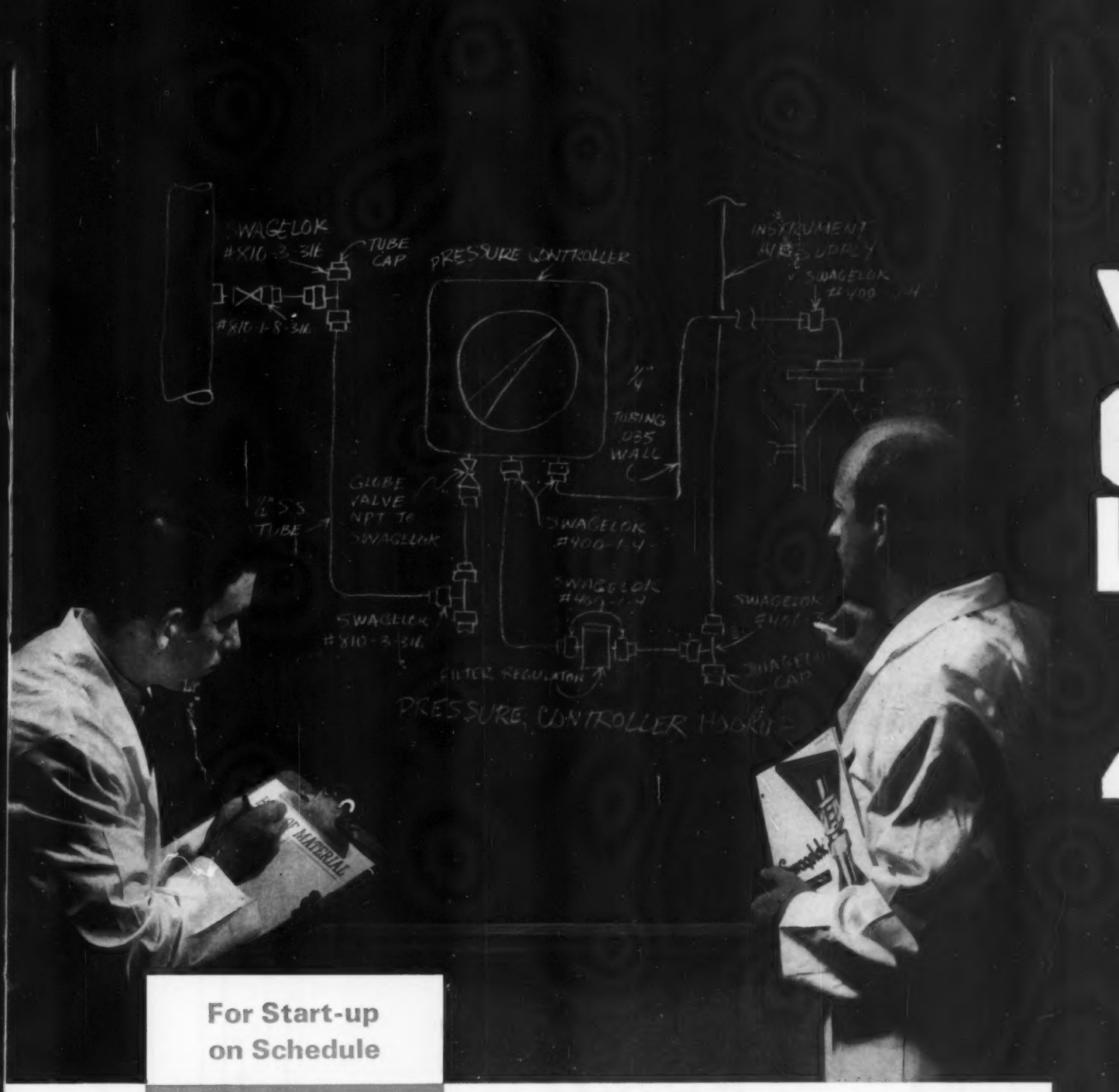
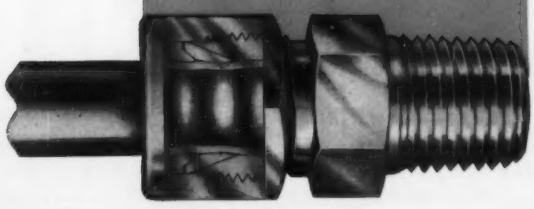


For Start-up on Schedule

Specify

Swagelok®

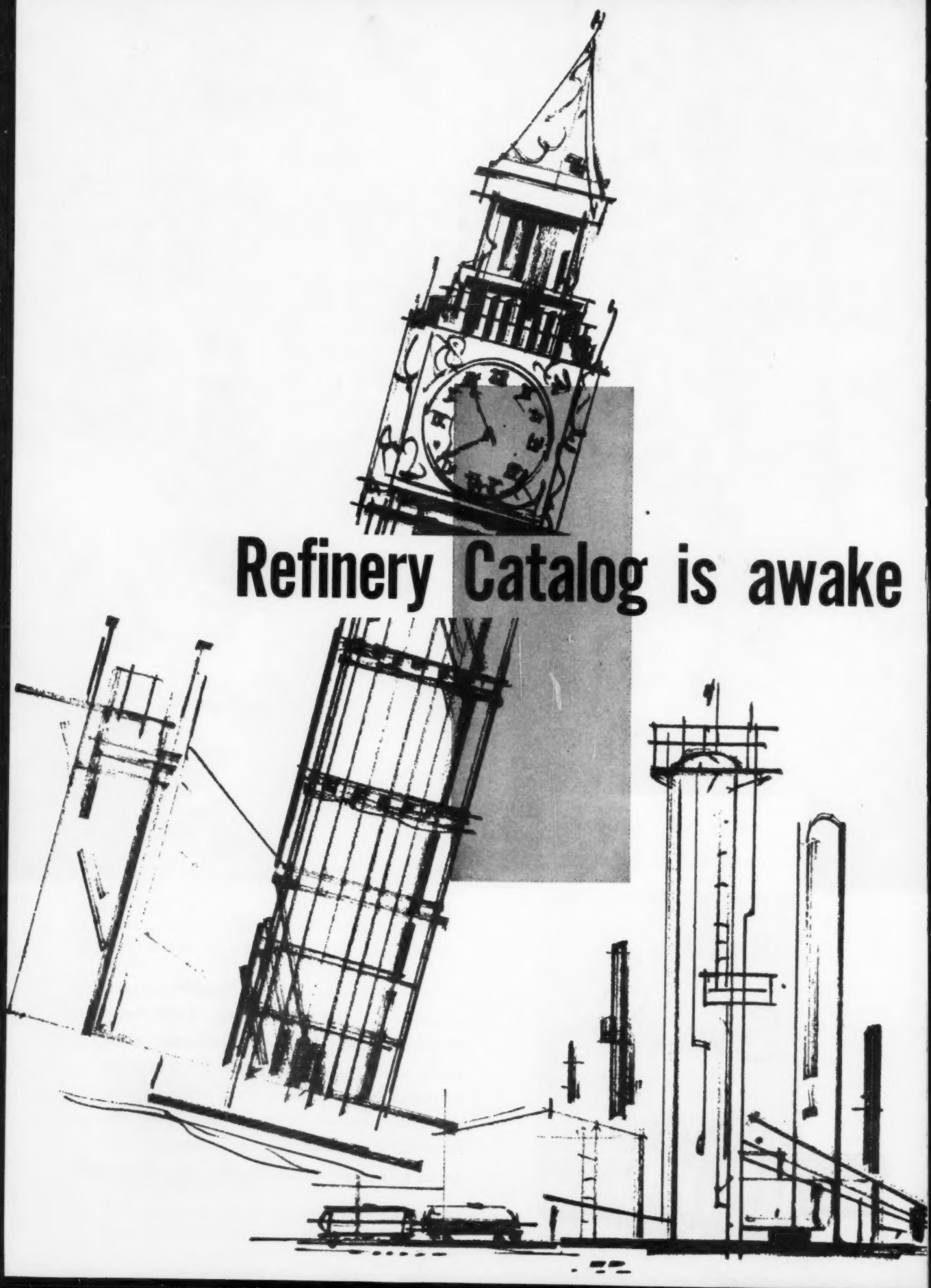


Don't Let Leaky Connections Cause Expensive Delay at Start-up

These engineers are specifying Swagelok for plant construction. The most severe test of tube fitting design and quality is in plant construction. Many plants have been built using 10,000 to 20,000 or more Swagelok tube connections without a leak. You can spend days to find one leak among the thousands of tube connections on a construction job.

Insure plant start-up on schedule—specify Swagelok

CRAWFORD FITTING COMPANY, 884 East 140th St., Cleveland 10, Ohio
CRAWFORD FITTINGS (Canada) LTD., Niagara Falls, Ontario, Canada



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World's Largest Specialized Publisher to the Oil Industries

It takes a Grade "A" barge to haul Grade "A" products

This is one of two all-welded steel chemical barges recently designed and constructed by American Bridge for the Union Carbide Chemicals Company. ☐ These barges have been certified by the U. S. Coast Guard to transport Grade "A" products in inland service! Mounted in each barge are six cylindrical tanks, also fabricated by American Bridge. Each tank is 52′ long x 14′6″ I.D. and has a nickel-plated interior to insure purity of the variety of products to be handled. ☐ Whatever your plate needs, American Bridge has the staff and facilities to take care of them, and our strategic location permits shipment by train, truck or barge. For our booklet completely describing plate fabricating and construction services, write American Bridge, Marine Department, Ambridge, Pennsylvania. USS is a registered trademark.

Marine Department: Ambridge, Pennsylvania—Houston, Texas
Ways at Ambridge, Pa., Trenton, N. J., and Orange, Texas

American Bridge
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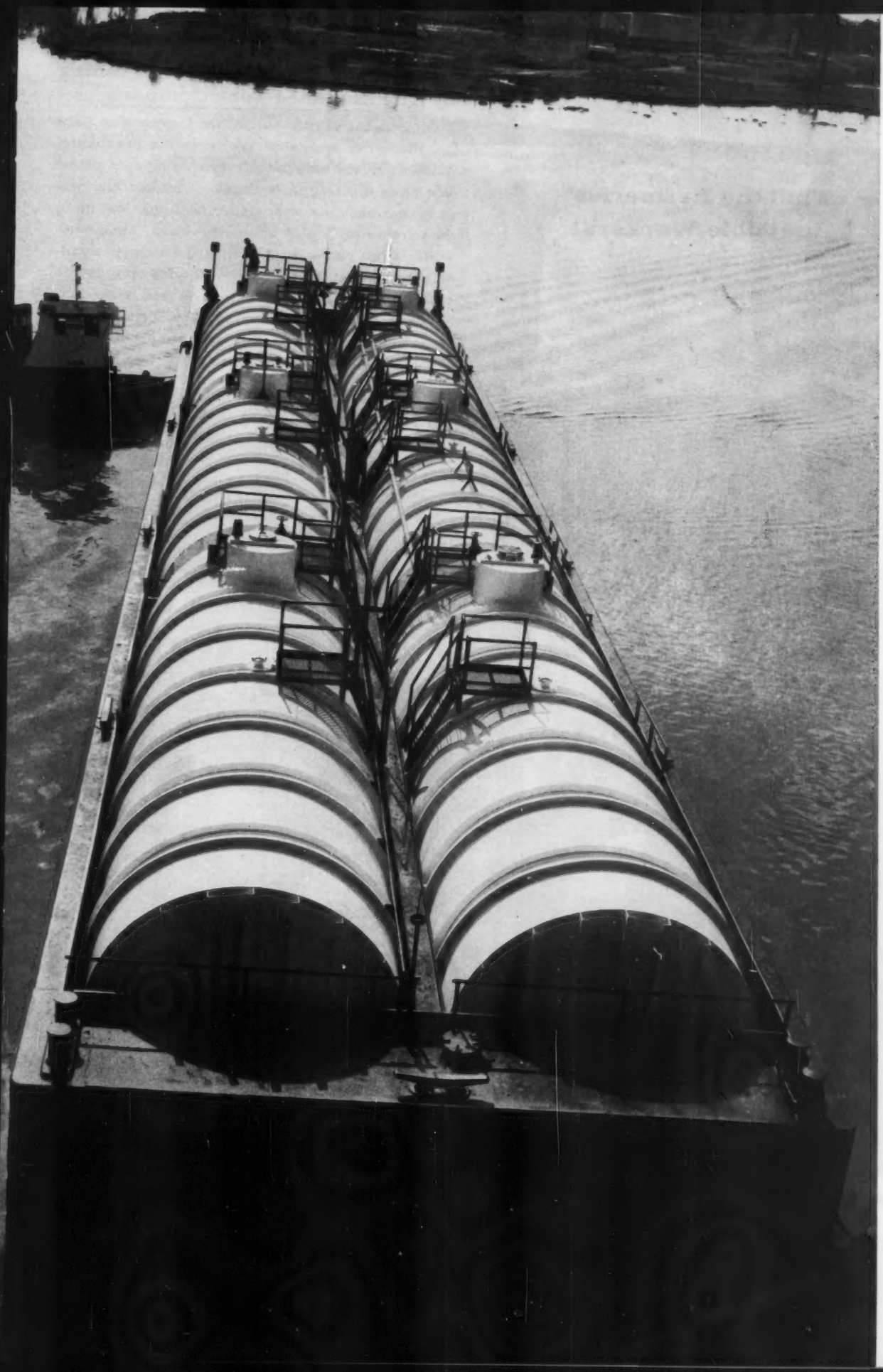
United States Steel



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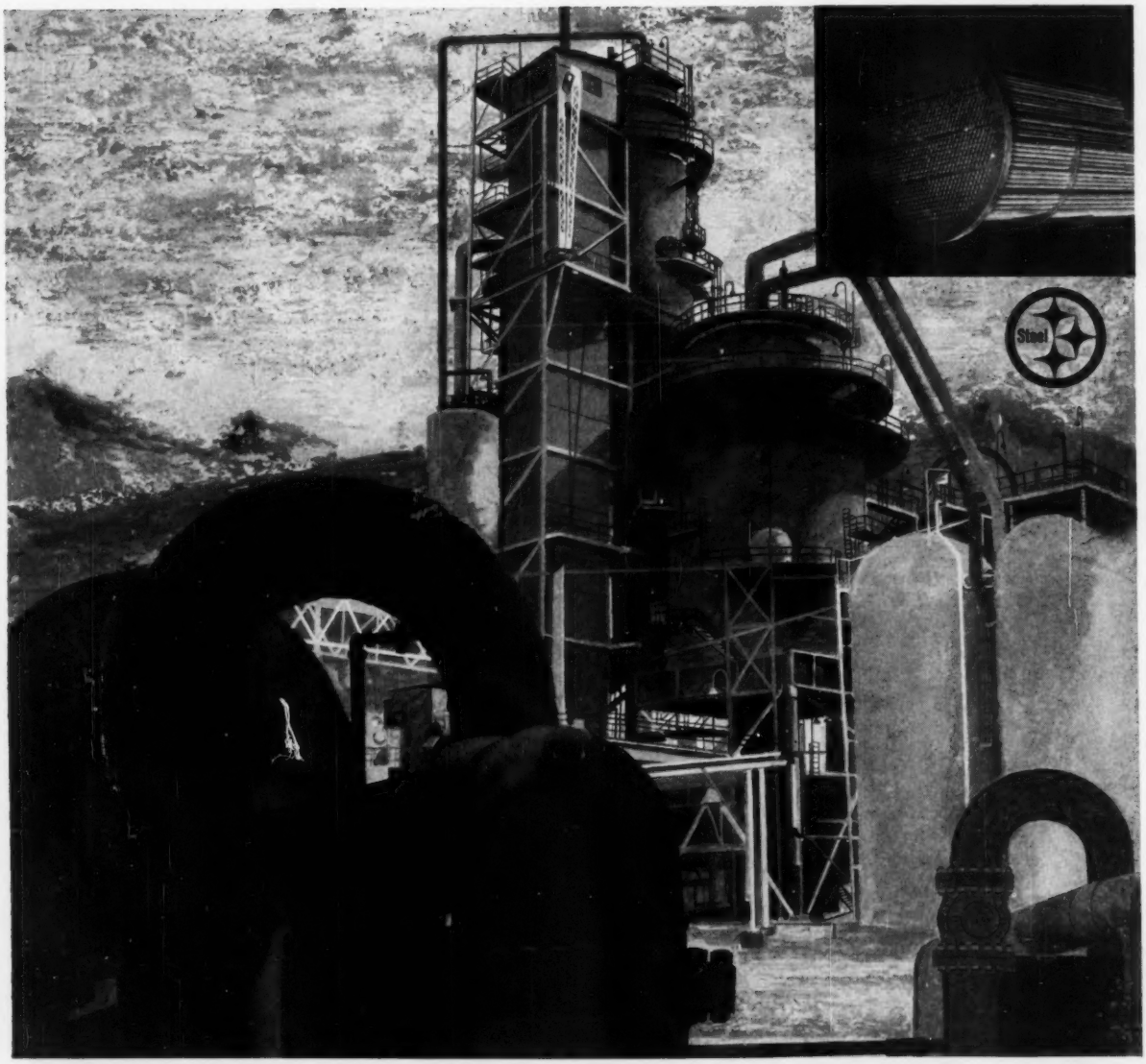
Tubing that is easy to roll-in, bend, expand or flare . . . that's our specialty. We have the production facilities . . . the tube industry's most modern plant! We have the testing facilities . . . hydrostatic and eddy current to surpass specifications. We have the personnel . . . most of our "tubemen" have been with us for years. And Standard tubing is available throughout the country. It all adds up to lower cost, higher quality and better service when you buy Standard welded tubing. For further information on our steel and stainless steel products and capabilities, write for brochure No. 6.



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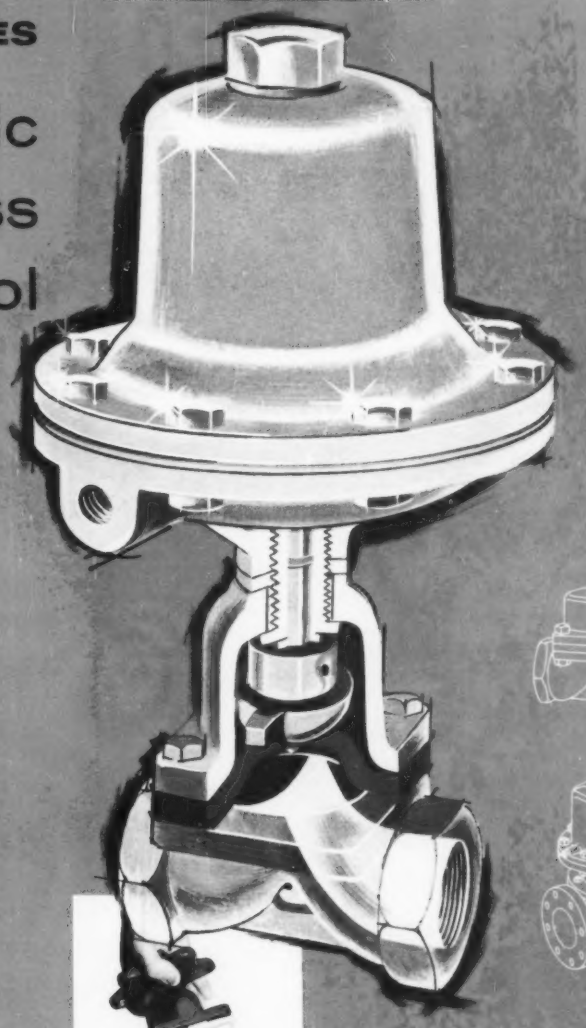
DIAPHRAGM VALVES

for automatic and remote process flow control



Here is economy . . . simplicity . . . reliability . . . accuracy for even your most difficult applications

WIDE RANGE OF AIR OPERATOR SIZES—no need to buy more operator than needed for a given size valve.

DRIPTIGHT SHUTOFF—will close tightly even against solid particles in the line.

ACCURATELY CONTROLLED THROTTLING — valves available with positioning devices for consistently reproducible control accuracy.

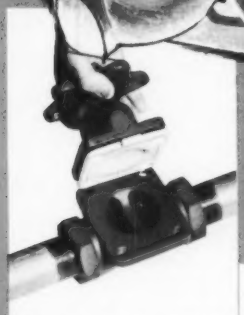
TYPES FOR EVERY JOB—including air open—air close, air open—spring close, and spring open—air close operation.

WORKING PARTS completely isolated from flow.

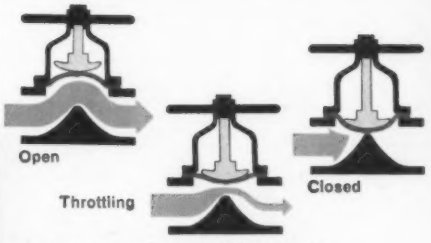
BODY AND DIAPHRAGM MATERIALS to handle paper pulp, acids, alkalies, oils, foods, beverages, fats, slurries, semisolids, viscous materials, compressed air, gases, volatiles, atomic reactor wastes, fuels, and hundreds of other fluids.

1/2" THROUGH 16" VALVE SIZES—with screwed, flanged, socket weld, and special end connections—for pressures to 150 psig and temperatures to 400° F.

ASK FOR NEW BULLETIN NO. 134-A giving complete selection data. Write for your copy today or call your nearby Hills-McCanna distributor.



Valves can be serviced without removing body from the line.



Accurate control plus bubble-tight closure even against solid particles which might lodge on valve seat. No packing—no leakage around stem.

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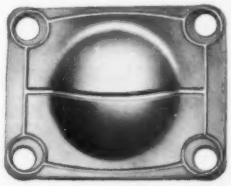
400 MAPLE AVENUE, CARPENTERSVILLE, ILLINOIS

Hills-McCanna (Canada) Ltd, 920 Mattawa Avenue, Summerville (Toronto), Ontario

Valves and parts stocked nationwide by leading industrial distributors.

What these valves really control is cost!

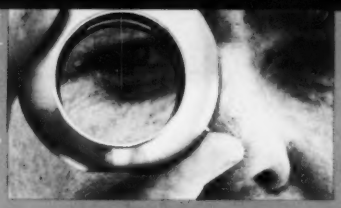
Tough, resilient diaphragms available in a wide range of elastomerics and plastics, including Chlorobutyl and solid Teflon.



you can see the sense to

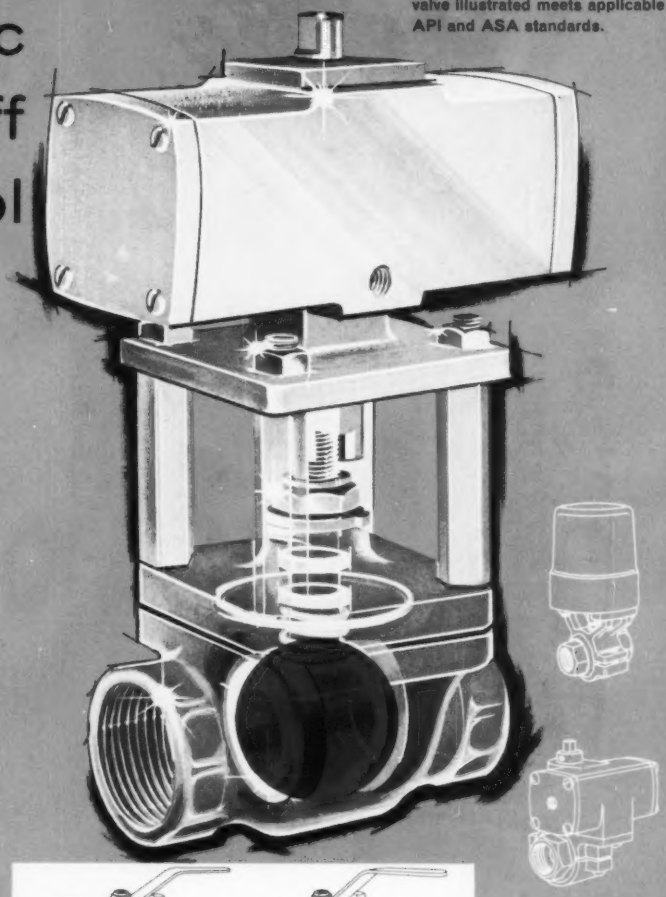
HILLS-McCANNA

BALL VALVES



for automatic and remote on-off control

McCANNASEAL® top-entry valve illustrated meets applicable API and ASA standards.



The only ball valves for service from -150° F to 1000° F

One look at a Hills-McCanna ball valve with pneumatic or electric operator tells you why it is a natural for remote flow control:

QUARTER-TURN OPERATION—permits use of a simple, economical, quick-acting operator.

LEAKTIGHT—line pressure forces closed ball tightly against downstream seat. Stem sealing is solved by twin seals illustrated below.

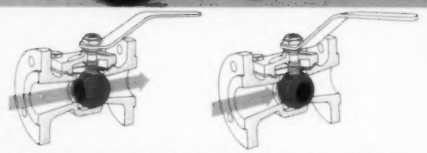
REMARKABLE VALVE WEAR LIFE because of smooth non-abrading contact between metal ball and nonmetallic seats.

1/4" THROUGH 12" SIZES—screwed, socket weld, flanged ends . . . pressures from 10^{-4} mm Hg to 1000 psig . . . temperatures from —150° F to 1000 F° . . . wide range of body materials for corrosive and noncorrosive services. "Fire-Seal"® seats available for leaktight closure under excessive temperatures.

PNEUMATIC OPERATORS—optional accessories include a solenoid valve for electrical control, limit switch for remote on-off operation, and a fail-safe device to return valve to open or closed position in event of air system failure.

ELECTRIC OPERATORS—weatherproof, explosionproof, rugged, and reliable.

SEND TODAY FOR NEW 32-PAGE CATALOG giving complete specifications and service recommendations for Hills-McCanna ball valves—manual and motor operation.



QUARTER-TURN OPERATION; low pressure drop. When the big, round, turbulence-free orifice is in line with the pipe, valve is wide open. A quarter-turn closes it completely against flow in either direction.

HILLS-McCANNA COMPANY

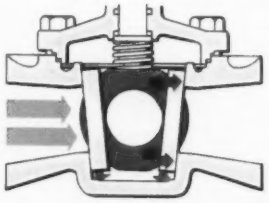
400 MAPLE AVENUE, CARPENTERSVILLE, ILLINOIS

Hills-McCanna (Canada) Ltd, 920 Mattawa Avenue, Summerville (Toronto), Ontario

Valves and parts stocked nationwide by leading industrial distributors.

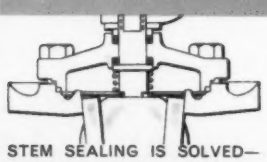
What these valves really control is cost!

BD61-2



NO FLOW LEAKAGE—line pressure forces closed ball tightly against the downstream seat. The seat seals against the valve body.

"WEDGE-SEAT" DESIGN of McCanna-seal valve compensates for wear—ball and seats are continuously wedged down into body under pressure of long-lived, corrosion-resistant, nonflexing, nontorsional spring.



STEM SEALING IS SOLVED—two seals are under compression by the stem nut which can be tightened to compensate for wear. Lower seal is back-seated—line pressure works with it to prevent leakage.

Litho in U.S.A.

ONE OF A SERIES OF CHATS ABOUT THE CONSERVATION AND CONTROL OF HEAT

SARCO TOPICS

WHY THE BIG STRAIN?

It's tough to keep gases and liquids "clean" as they run through a pipe. They drag impurities along, which can make even plain water a trouble maker, let alone more sophisticated fluids. That's because water, as a liquid or steam, is intimately involved with vital equipment like steam traps, temperature regulators, or tools. Meters, burners, nozzles, and pumps, too.

By this time you must realize we're going to talk strainers, don't you? A good, stout subject, of interest to all who feel production belongs up and costs belong down. Sarco makes strainers for water and condensate, steam, oil, air, gas and other piped fluids . . . dozens of different sizes and types and ratings of strainers to match every application need. Even our line of plain and simple strainers is built for super service. These are pipeline strainers, types AT, BT, and CT, which are designed for 250, 250 and 600 psi non shock, respectively, and 475°, 450° and 750°F. temperature ratings. Standard screens are heavy-gauge, perforated brass or stainless steel. Sarco specializes in screens that can withstand abnormal pressure differentials created by accumulated sediment.

Next, Sarco's flanged strainers, type D. These come in larger sizes, right up to 12", and are available in standard or extra heavy types.

And finally, *Sarco scraper strainers*, manual or motorized. These are the really eye-popping models, and if you can't use one yourself — well — you'll just have to get your kicks elsewhere.

Examples? Take Inland Steel Company at East Chicago, which gets water from Lake Michigan to cool its large air conditioner condensers. The water used to pass through traveling screens, but still contained fine sand. Clogging!

Heat under collars! Frequent cleaning required! Sometimes practically no air conditioning on hot days. (Isn't that always the way?)

The Inland Steel people installed Sarco Rotary Scraper Strainers, Type VRS, which incorporate a hand-operated helical scraper knife within the cylindrical strainer screen. A few turns of the crank at regular intervals, and the sand is scraped off the screen, blown clear, and discharged at pressure through a manual valve to waste. Dismantle the strainer? Shut down the unit? Not *this* strainer!

Now, as long as we've come this far, it's only a hop and a skip to the Firestone Tire and Rubber Co. in Akron, Ohio, who also use water in tremendous quantities. They circulate it through tire presses and a cooling tower, and there's no nonsense about it. It *has* to be clean or damage to equipment could be downright catastrophic. When the plant

modernized and enlarged, Firestone replaced their 4" Sarco hand-operated scraper strainer, type VRS, with a larger Sarco 8" model. And while they were about it, they got the motor-operated type, for continuous cleaning.

When we say that companies like these want the insurance of a Sarco strainer, it sounds like advertisingese, but sometimes there just isn't any other way to put it. Sarco strainers *are* insurance at low cost on the operation of your high cost equipment. So when we ask if you have lumps in your pumps, or worries over your slurries, we're *serious*. We've heard everything in the straining line, so why not write us for literature and answers to those special problems you have.

A T-44 IS THE BEST POLICY

Sorry, but we can't leave the subject of insurance without bringing to your attention one of the best little insurance policies any company requiring cooling control could invest in. It's the *self-powered* Sarco T-44 Automatic Cooling Control. No compressed air or electricity is needed, but its advantages are best described in terms of three different plants of just one Sarco customer — Revere Copper and Brass, Inc.

Revere-Baltimore, Md., has cut water use 40 to 50% with T-44's. But in addition to former water waste, Revere had even more problems: possible wet air from uncontrolled cooling of compressor aftercoolers, plus sweating compressor cylinders; variations in viscosity of hydraulic oil and bearing oil; gas generator water waste; unreliability of manual shut-off of water supply when machines were down.

If your ears perk up in sympathy at mention of any of these problems, the results of Revere's cooling control program should bring you to full attention. One large compressor that had gulped 2400 gallons per hour now takes only 420 gallon sips. In addition all the problems itemized above were solved. T-44's are now used on their air compressors, gas generators, and hydraulic oil systems. At Revere-Riverside, Cal., water savings of 50% were experienced, and at Revere-Rome, N. Y., substantial savings were made too.

But after all, wasting water is only one way of wasting money, so let's go on to another matter of interest: the evils of manual control. When cooling water is controlled by hand the temptation to leave the valve nearly wide open is almost overpowering, in order to play it safe if the load varies. Result: overcooling, of course. And varying the flow runs the risk of undercooling. In either case, lowered process efficiency. Answer: The automatic Sarco T-44, which can't be tempted, is meticulously honest, unsentimental, and plain inhumanly practical when it comes to cooling control. You really ought to write for literature. T-44 is your best policy.

SPARE PARTS INSURANCE

As long as we're near the end, and still on this subject of insurance, may we graciously leave you with this valuable tip? No matter how closely a steam trap approaches perfection, some gremlin may cause it to act up. It's conceivable. So, keep on hand a parts list and spares of key parts for your steam traps and other system components. Parts are small and worth their weight in gold when you need them. A Sarco field engineer will make up a suggested list for you, if you tell us what components make up your system.

Might as well even keep a disc or two on hand for your Sarco Thermo-Dynamic Steam Traps, Type TD-50, even though they're so trouble-free our salesmen keep complaining about the lack of replacement parts business. We'll be glad to tell you about this unique steam trap in case you still don't know how miraculously simple and effective it is.

Pardon our monopolizing the conversation in this series of paid communiques, but we're trying our best to interest you in certain subjects that concern us both — to the point where you'll communicate.

5903

SARCO

SARCO COMPANY, INC.
635 MADISON AVENUE, NEW YORK 22, N. Y.
PLANT: BETHLEHEM, PA.
STEAM TRAPS • TEMPERATURE CONTROLLERS
STRAINERS • HEATING SPECIALTIES

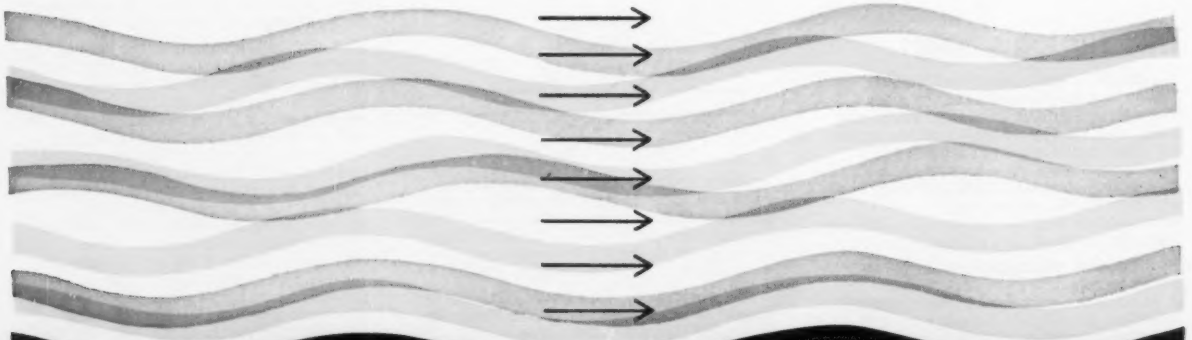
For more data on advertised products, use cards, last page.

Honeywell announces the NEW series 1400 low flow control valve

The addition of the new Series 1400 valve body to the Honeywell line of control valves now gives you a choice of actuator-body combinations to match your applications. Now you can choose the exact type and degree of control you need, without pushing a valve beyond its design limits . . . or without paying for more performance than you need.

The compact Series 1400 valve body is available in a full range of materials, ratings and sizes, with screwed or flanged ends. It can be used to regulate small flows in process, pilot plant, research and commercial control systems. Each body size (½", ¾" and 1") has a wide range of reduced ports with Cv's from .025 to 11.0. Two bonnet constructions facilitate mounting of five types of actuators —three pneumatic and two electric.

Each actuator-body combination fits a different range of operating conditions and performance characteristics, but with sufficient overlapping of these ranges to give you a wider selection on the basis of cost. For complete details, write for Bulletin B803-1. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.



Model 1401 Low Flow Valve with heavy-duty pneumatic actuator for systems requiring high shut-off ratings and accurate valve positioning.

Model 1403 Low Flow Valve with compact, light weight pneumatic actuator for average industrial and commercial control systems.

Model 1404 Low Flow Valve with reduced port Cv's to .025 and top-mounted positioner integral with pneumatic actuator.

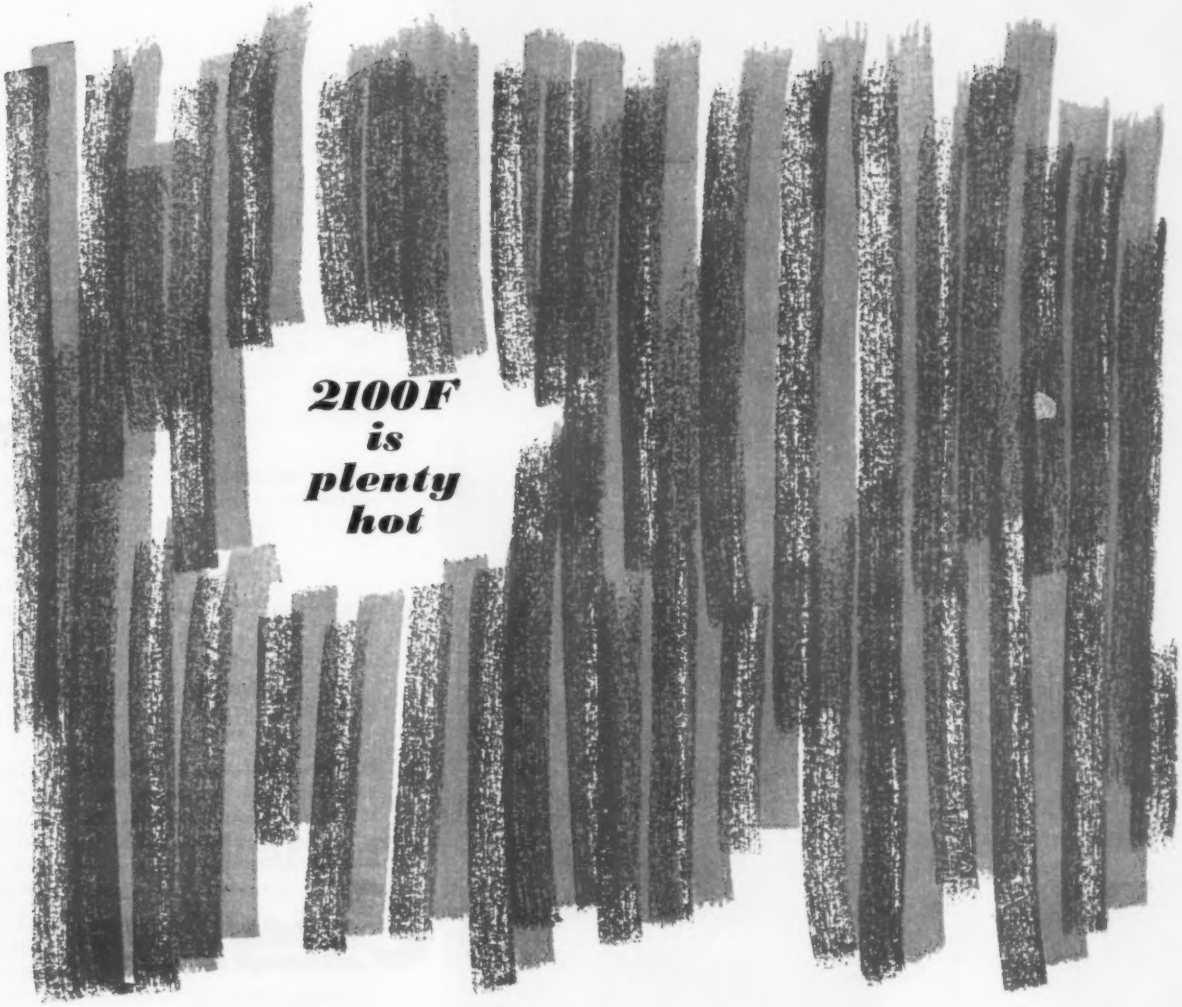
Model 1406 Low Flow Valve with *Modutrol* capacitor-type, electric motor actuator for two-position, floating or proportional control.

Model 1407 Low Flow Valve with heavy-duty *Actionator* electric motor actuator provides more power for higher valve shutoff ratings.

Honeywell

H First in Control

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.



new B-E-H

#1 plus *insulating cement can take it*

Heat protection hits a new high in B-E-H #1 Plus Insulating Cement for uneven surfaces, fittings, pipes and valves. Now effective up to 2100 F . . . B-E-H #1 Plus provides a comfortable margin of protection that insures excellent thermal efficiency even on installations not normally subject to super-high temperatures.

Plus in performance – the more resilient fibers and special binder developed by B-E-H research produce a whiter finish that looks better – handles easier – sets smoother.

Plus economy – priced dead-level with other high-quality insulating cements. B-E-H #1 Plus provides an additional 300 F of effective insulation, a whiter, smoother finish, and easier mixing and handling. It pays to specify B-E-H #1 Plus for every job.

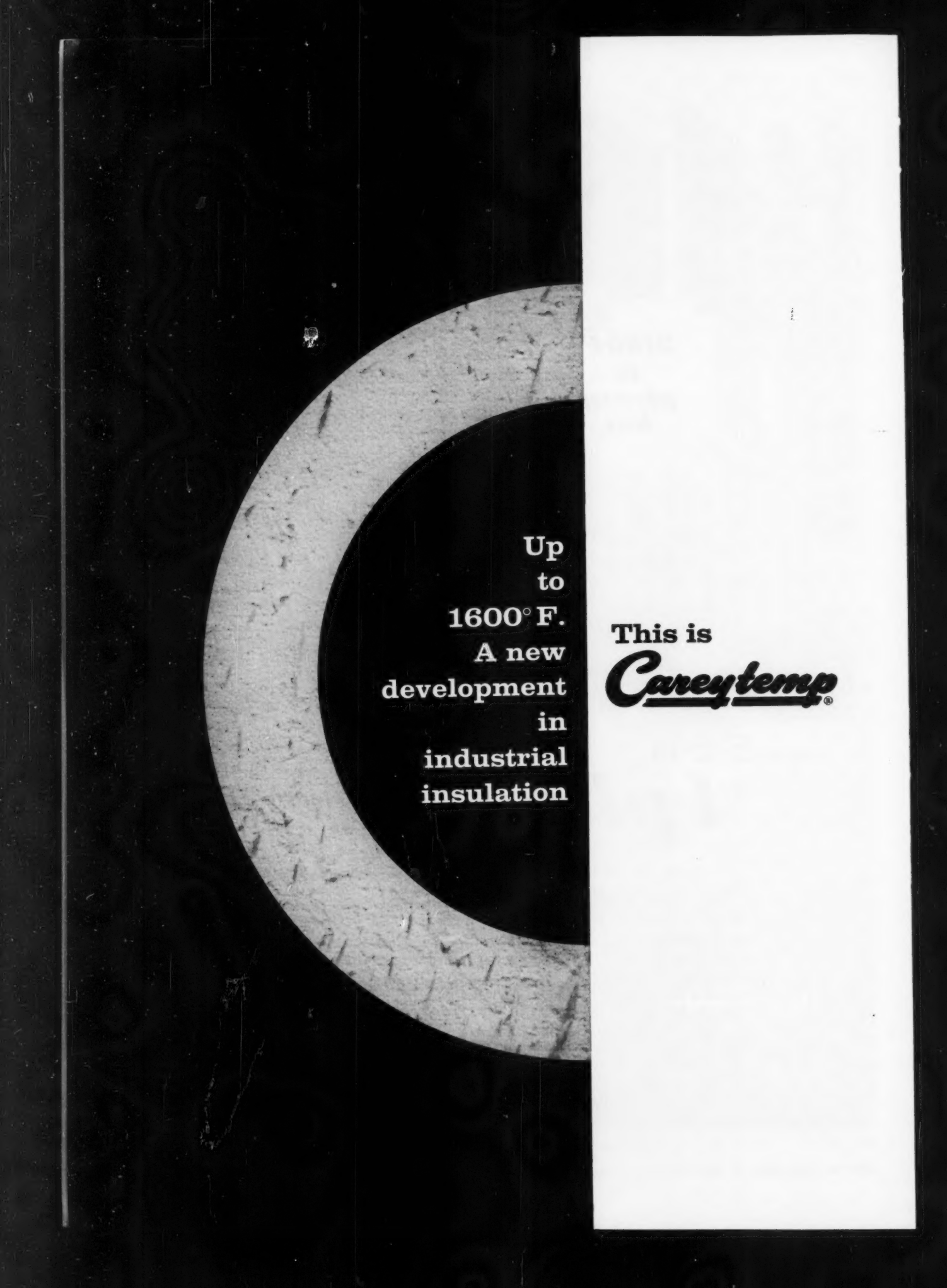
For complete technical data and name of your nearest qualified Baldwin-Ehret-Hill distributor-contractor, write: Baldwin-Ehret-Hill, Inc., Room 201, Trenton 2, N. J.

BEH BALDWIN EHRET HILL

BALDWIN-EHRET-HILL, INC.

Manufacturers of a complete line of pipe, block, felt and blanket insulation for temperatures from near absolute Zero to 2100 F.

For more data on advertised products, use cards, last page.


Up
to
1600° F.
A new
development
in
industrial
insulation
This is
Careytemp®

Composition
A new pipe and block insulation material . . . millions of glassed-in air cells of expanded silica bound together, reinforced with inorganic fibres. Gives exceptional strength, yet is lighter than other industrial insulations. Density: 9 lbs. per cu. ft.

High Moisture Resistance
Absorbs practically no moisture. Minimum efficiency loss under wet or humid conditions.

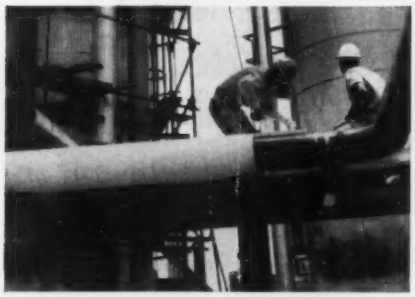
Low Shrinkage
Practically no linear shrinkage, even at high temperatures (0.7% at 1200° F.). Minimum heat loss at joints.

Low Thermal Conductivity
Only .33 B.T.U./sq. ft./hr./°F. at 100° F. — .77 at 1000° F. mean.

High Acid & Corrosion Resistance
Improved performance on acid-processing and stressed stainless steel equipment. Not damaged by most acids. Chemically-inert composition ideal where corrosion is a problem.

Wide Size Range
Available in larger labor-saving sizes. Blocks in new 24" widths and pipe insulation in half sections through 24" pipe size.

Over four years of field use have proved Careytemp, following thorough laboratory testing at Mellon Institute of Industrial Research. For Careytemp samples and additional specifications, write Dept. PR-1061, Insulation Division, The Philip Carey Mfg. Company, Cincinnati 15, Ohio.



Applying Careytemp pipe insulation on Plymouth Oil Company's new UOP Udex aromatics extraction unit at Texas City, Texas. General contractor: Procon Incorporated, Des Plaines, Ill. Insulation contractor: B & B Engineering and Supply, Houston, Texas.

THE TWO OUTSTANDING

PLATINUM REFORMING CATALYSTS

ENGELHARD
INDUSTRIES, INC.
CHEMICAL DIVISION
113 ASTOR STREET · NEWARK 2, NEW JERSEY

IMPORTANT NOTICE:

These two well established platinum reforming catalysts having distinctive product distribution patterns are now manufactured by Engelhard and supplied under a single license and catalyst supply contract. This new, singular service advantage allows you to choose the catalyst best suited to particular processing or economic conditions in a given installation. Greater latitude in reforming results thus assures maximum economy in each individual refining operation.

Investigate the unique performance of these outstanding platinum reforming catalysts. They provide longest periods of operation — *regeneration in situ!* They deliver important yield increases at high octane levels — *in existing equipment!* They reduce costs sharply—*to lowest level!*

An Engelhard representative will be glad to give you detailed information upon request. ★ ★ ★

PROMPT PRECIOUS METAL SCRAP RECOVERY SERVICE • ENGELHARD PROCEDURES RECOVER 100% OF ASSAYED PRECIOUS METAL CONTENT • IRVINGTON-BAKER REFINING DIVISION

Here's Why
Oil Men Specify—

EC&M
HIGH VOLTAGE STARTERS

2200-4800 VOLTS
FOR
PRESSURIZED ROOMS
OUTDOORS
INDOORS

left • Type AH Starter (50,000 KVA, certified) for Division 2 Applications. NEMA 3R (raintight) Enclosures for mounting outdoors
below • Diesel loading pump station in southwestern refinery

EC&M Starters are standardized for *easy selection.* They are *easier to install* because they are shipped with all internal wiring complete. They are designed for *easier, faster inspection and maintenance.* And—they *save valuable space* because they are compact with no sacrifice in accessibility.

EC&M's Type AH Starters are available in NEMA 1 or 3R (raintight) enclosures for outdoors, indoors or pressurized control rooms. Three interrupting ratings: 50,000 KVA—POWER FUSED—and VALIMITOR®

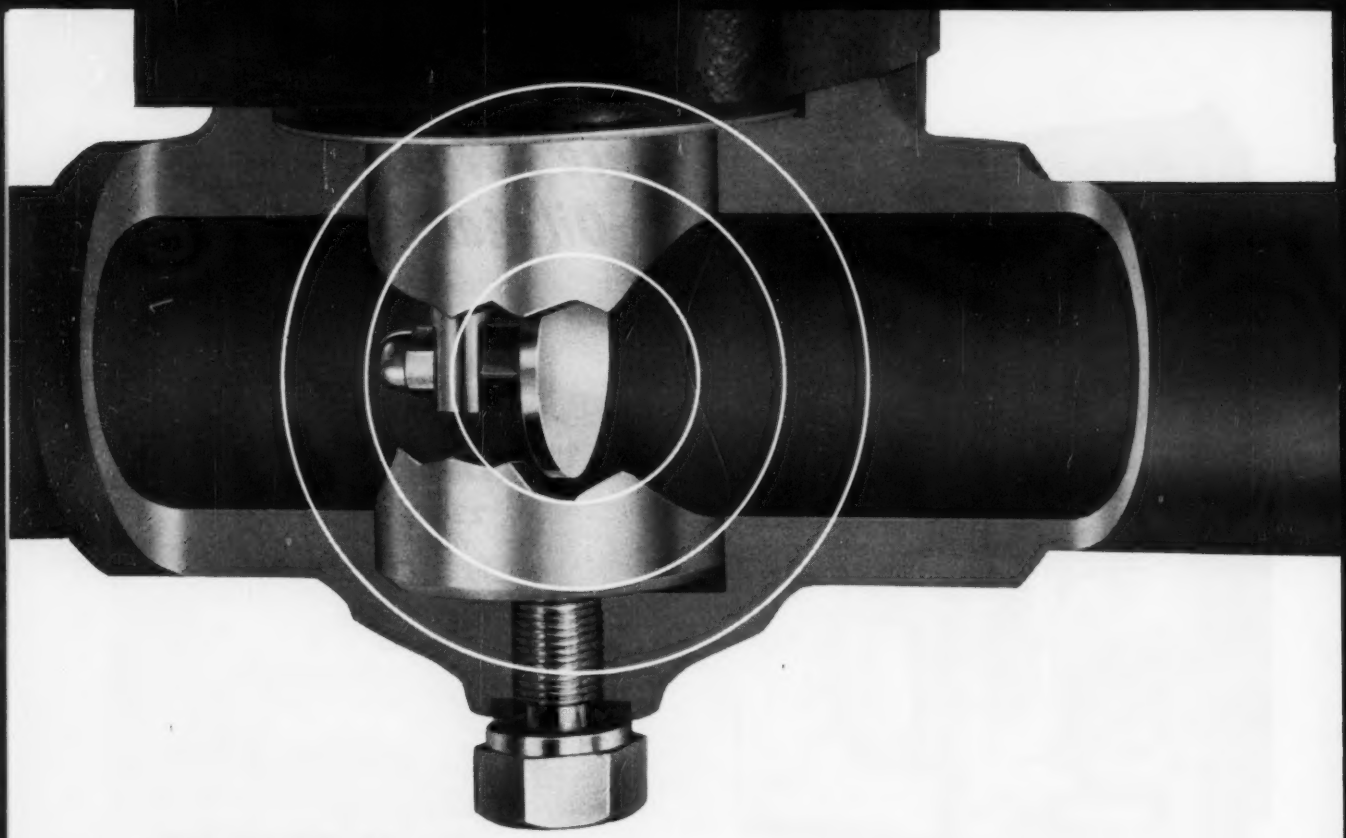
***Write* for Bulletin 8130**

Five EC&M Aligning Starters with Incoming Line and Feeder Panels for Pumps and Compressors (Pacific Coast Refinery)

Pressurized Control Room with ten NEMA 1 EC&M Enclosed Starters in midwest refinery

SQUARE D COMPANY
EC&M DIVISION • CLEVELAND 28, OHIO
wherever electricity is distributed and controlled

8019



improved way to high measurement repeatability . . . the Foxboro Target Flow Meter

designed for the "tough ones"... hydrocarbons, heavy oils, and viscous liquids up to 750 F – installs directly in line . . . no pressure taps to foul or plug up – high repeatability – low maintenance – write for TI 37-84a, or contact your Foxboro Field Engineer.

The Foxboro Target Meter is installed directly in the flow line. A stainless steel "target," extending into flow stream, senses force of fluid pushing against it. Force is then converted to a pneumatic signal and transmitted to a remote Foxboro recorder or controller.

FOXBORO

REG. U. S. PAT. OFF.

THE FOXBORO COMPANY
7410 Neponset Ave., Foxboro, Mass.

NOBODY OFFERS MORE CATALYST KNOW-HOW

To bridge the gap between selection of a catalyst and getting the most usefulness from it, HOUDRY offers you a background of more than 30 years' intensive experience in process design and operation—along with basic experience and proved capability in catalyst design and manufacture.*

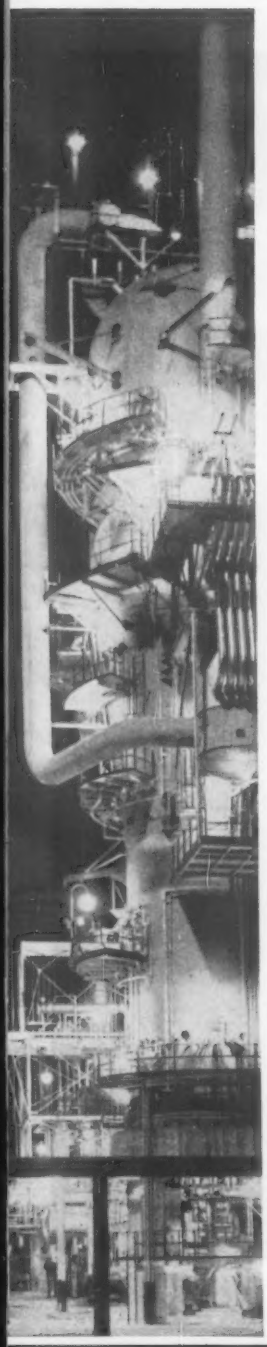
HOUDRY catalysts for petroleum, petro-chemical and chemical processing are not only highly developed products, but are also proved in actual commercial use dating from the origination of commercial-scale catalytic processing. And in developing a wide range of catalysts, perfecting them, and bringing them to their fullest practical value, HOUDRY catalyst service personnel have also developed and perfected techniques and procedures . . . which make HOUDRY catalysts yield maximum usefulness for processors who choose them.

HOUDRY
PROCESS CORPORATION
1528 Walnut Street, Philadelphia 2, Pa.
*Houdry means Progress...through Catalysis

For more data on advertised products, use cards, last page.

KELLOGG Leads Repeatedly

in Cat Cracking....



EXTENSIVE EXPERIENCE AND IMPROVED DESIGN ASSURE OPTIMUM UNIT FOR ANY NEED...

A substantial portion of today's total fluid catalytic cracking capacity bears the imprint of Kellogg engineering and construction techniques. This unparalleled experience, coupled with improvements in Orthoflow® design, enables Kellogg to provide the optimum unit to meet any need in any part of the Free World.

Kellogg's leadership in cat cracking is based upon a continuing program of design improvement. Both in the company's New York engineering offices and Jersey City laboratories, Kellogg specialists have achieved numerous improvements in product quality and yields while reducing investment, utility, and catalyst costs.

The latest developments in Kellogg's Orthoflow design permit use of greater variety of feedstocks and provide improved product distribution, more operational flexibility, and still higher yields of gasoline and lower yields of coke—all with less capital investment and upkeep than ever before.

Whatever your cat cracking needs . . . modernization . . . expansion . . . completely new facilities . . . Kellogg welcomes the opportunity to discuss how it can work to your economic advantage.

THE M. W. KELLOGG COMPANY

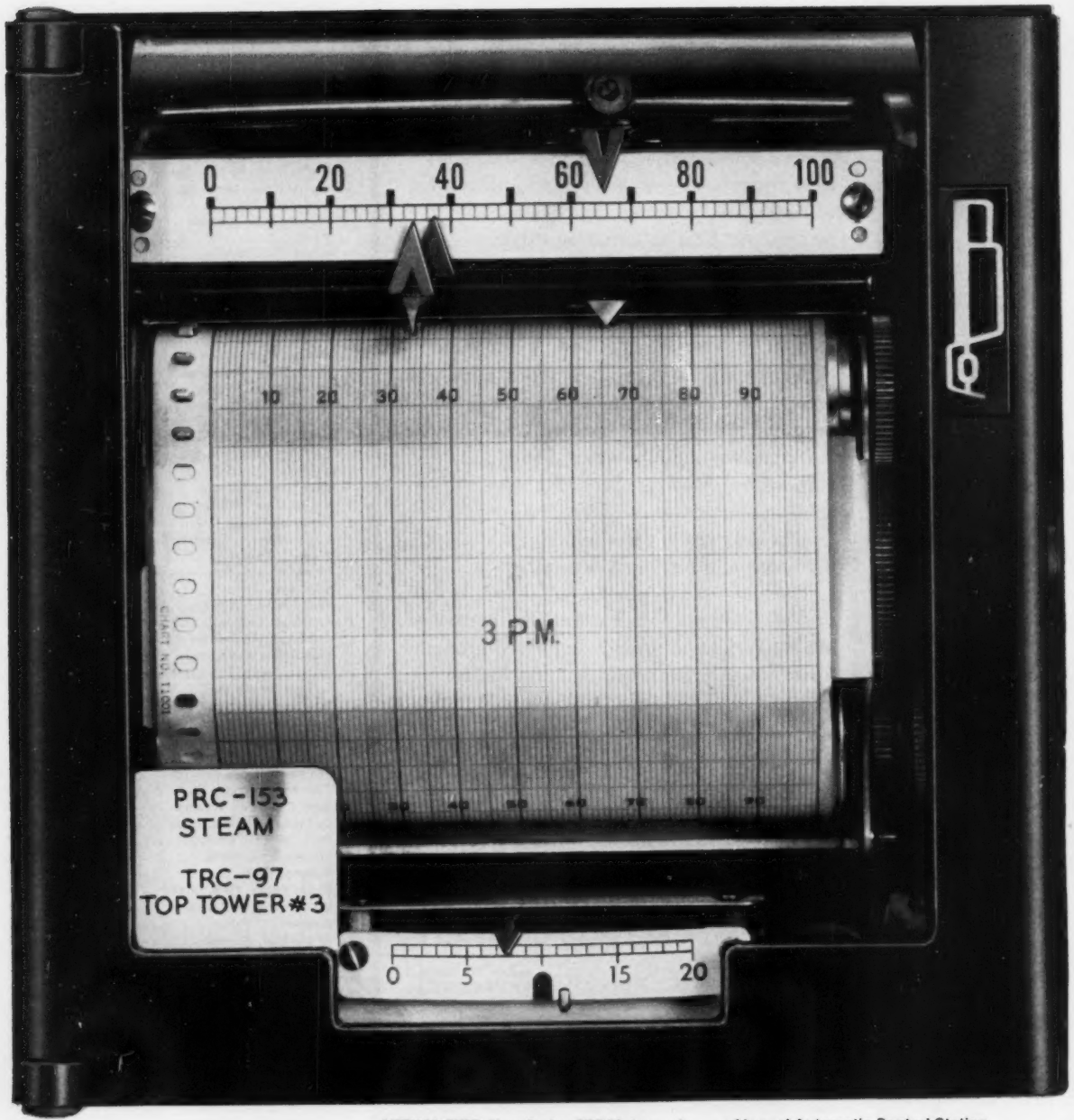
711 Third Avenue, New York 17, N.Y.
Subsidiary of Pullman Incorporated

THE CANADIAN KELLOGG COMPANY, LIMITED, TORONTO
KELLOGG INTERNATIONAL CORPORATION, LONDON
SOCIETE KELLOGG, PARIS
DEUTSCHE KELLOGG INDUSTRIEBAU G.m.b.H., DUSSELDORF
KELLOGG PAN AMERICAN CORPORATION, BUENOS AIRES
COMPANIA KELLOGG de VENEZUELA, CARACAS
COMPANHIA KELLOGG BRASILEIRA, RIO DE JANEIRO

LOCATION	TOTAL THRUPUT BPD
Edmonton, Alberta	3,784
Ponca City, Oklahoma	24,480
Sarnia, Ontario	14,027
Gelsenkirchen, Germany	5,000
Amarillo, Texas	9,706
Sisak, Yugoslavia	3,332
Toledo, Ohio	17,705
Smiths Bluff, Texas	26,625
Philadelphia, Pennsylvania	45,000
Clarkson, Ontario	45,000
Kwinana, Australia	12,500
St. Boniface, Manitoba	9,837
Enid, Oklahoma	19,330
Delaware City, Delaware	101,800
Yorktown, Virginia	30,618
Puerto La Cruz, Venezuela	14,290
Mataripe, Brazil	20,493
Vancouver, British Columbia	13,500
Montevideo, Uruguay	7,000
Concon, Chile	14,400
Mendoza, Argentina	18,783
Borger, Texas	34,830
Texas City, Texas	95,160
Istanbul, Turkey	9,380
Baton Rouge, Louisiana	17,000
Baytown, Texas	14,700
Baton Rouge, Louisiana	15,500
Dominques, California	18,700
Aruba, Netherlands W.I.	15,000
Baltimore, Maryland	15,000
Wood River, Illinois	17,050
Port Arthur, Texas	22,000
Lake Charles, Louisiana	23,400
Parco, Wyoming	9,350
Lake Charles, Louisiana	16,286
Texas City, Texas	17,050
Port Arthur, Texas	17,050
Wood River, Illinois	17,600
Salt Lake City, Utah	14,500
Lake Charles, Louisiana	17,435
Sarnia, Ontario	29,000
Baton Rouge, Louisiana	15,500
Baytown, Texas	15,500
Wood River, Illinois	10,000
Whiting, Indiana	20,000
Wilmington, California	16,275
Dinslaken, Germany	10,000
Philadelphia, Pennsylvania	21,030
Casper, Wyoming	6,000
Whiting, Indiana	67,710
Lockport, Illinois	22,400
Sugar Creek, Missouri	20,000
Heath, Ohio	5,000
Montreal East, Quebec	30,358
Tulsa, Oklahoma	16,200
East Chicago, Indiana	46,500
Casper, Wyoming	8,000
Port Arthur, Texas	90,000
Montreal, Quebec	11,000
Toledo, Ohio	30,635
Eagle Point, New Jersey	33,250
West Tulsa, Oklahoma	19,523
Cincinnati, Ohio	19,375
El Dorado, Kansas	22,810
Montreal East, Quebec	21,588
Lawrenceville, Illinois	35,150
Port Arthur, Texas	67,093
Winnipeg, Manitoba	3,740
Grangemouth, Scotland	13,000
Llandarcy, Wales	17,930
Isle of Grain, England	13,500
Philadelphia, Pennsylvania	63,750
La Plata, Argentina	26,165
Port Arthur, Texas	68,000
Gonfreville, France	31,370
Campana, Argentina	14,040

For more data on advertised products, use cards, last page.

NEW.



ACTUAL SIZE. New Series 670 Metagraphic is ideal for graphic panel applications, occupying panel space only 7" wide by 7⅛" high. Fits into 6" by 6" panel cutout. Typical 670 Series models available, include:

- 1-Pen, 2-Pen, or 3-Pen Receiver
- Manual-Automatic Control Station
- Manual-Cascade Control Station
- Manual-Automatic-Cascade Control Station
- Single-Case Cascade Control Station

here's the pneumatic receiver you asked for!

Bristol's new 4-inch-chart Metagraphic receiver

is the easiest yet to install, operate, and service

Never before has a 3-15 psi pneumatic receiver been designed with such exacting, meticulous attention to the needs of the graphic panel designer, the instrument user, and the instrument maintenance man.

Bristol's new Series 670 Metagraphic receiver brings you the plug-in versatility and operating convenience—made famous in previous Metagraphic pneumatic receivers—plus the increased legibility and accuracy of a 4-inch strip chart, plus these big new features:

Simplified control switching between functions... allows the easiest start-up procedure for either the common manual-automatic station or the more complex, single-case cascade control station models. Intermediate "seal" position has been eliminated. Just adjust process to line-up color-coded indicators and switch to automatic or cascade operation as desired.

Uniform control switching . . . all receiver models have the same switch positions for the various types of control —cascade position, 3 o'clock; manual position, 6 o'clock and automatic position at 9 o'clock.

Simplified chart change and inking . . . chart changing is a one-hand operation. A new chart can be slipped into place in an instant. The capillary inking system can be refilled from the front of the receiver.

And the new Metagraphic receiver gives you other outstanding features such as rectilinear chart coordinates for easiest reading, easy connections for any type of control, either field or receiver-mounted controllers; and sparkless, mercury-switch disconnect of electrical circuit when chassis is removed.

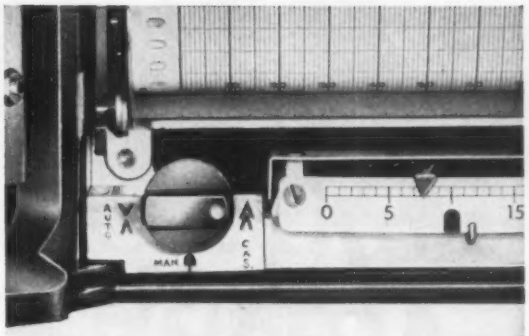
Get the complete story on the new Bristol Metagraphic receiver today. Write The Bristol Company, 111 Bristol Road, Waterbury 20, Conn., a Subsidiary of American Chain & Cable Company, Inc. 0.42

ACCO

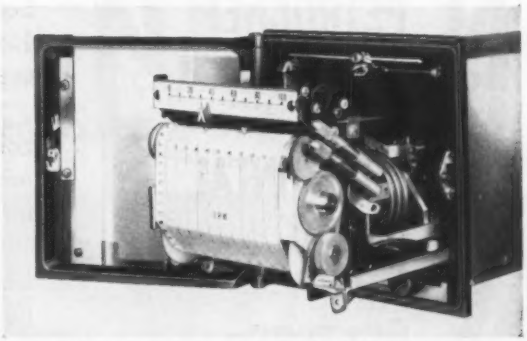
BRISTOL

...for improved production through measurement and control

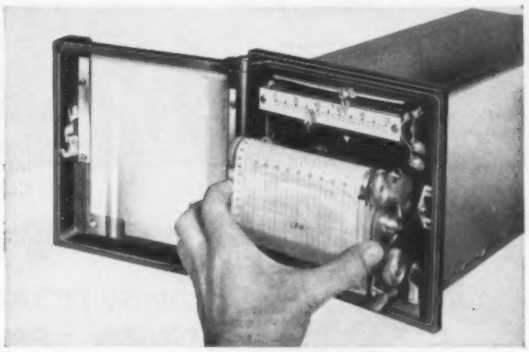
AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



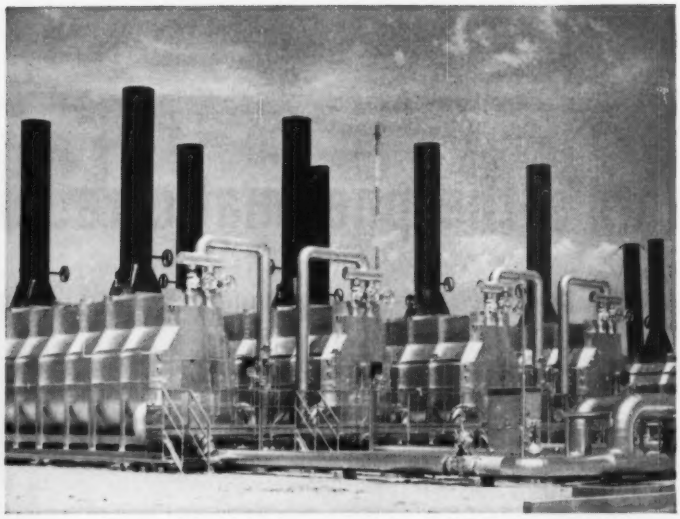
Simplified control switching is keynote of new receiver's design. For instance: uniform switch positions on all models avoid operator confusion in multi-receiver installations; simple alignment of color-coded pointers and a single switching operation put complex automatic or cascaded systems "on stream."



Complete "plug-in" service continuity. Entire plug-in receiver chassis is instantly replaceable with spare for complete continuity of service. Control functions are not disturbed when receiver chassis is removed.



Easiest to service . . . For instance: Easily removable chart drive mechanism—a one-handed operation—permits exceptionally fast chart replacement; just slip out drive, replace with spare, replace paper in original drive at leisure.



100,000 to 200,000,000 BTU

PETROCHEM VERTICAL AND HORIZONTAL DIRECT FIRED HEATERS

For the petroleum, chemical and petrochemical industries, Yuba now offers the most complete series of direct-fired heaters available. From 100,000 to 200,000,000 BTU per hour – from -200° to +2,000° F – Petrochem Vertical and Horizontal Heaters can be built in every size and type for every use in any location!

Yuba Heaters are available from the most simple horizontal design to the famous Petrochem vertical with optional reradiation cones for even heat distribution and maximum efficiency.

Working closely with both customer and prime contractor, Yuba can provide single piece, shop-assembled horizontal heaters *to 30,000,000 BTU*. Other heaters up to 50,000,000 BTU can be provided in two sections. For field installations of larger heaters, Yuba can provide well-trained supervisory personnel when desired. Get the complete story on Petrochem direct-fired heaters from Yuba – your largest single, fully-integrated source of supply.

Other Yuba Products For The Petroleum, Chemical and Petrochemical Industries—Adsco Expansion Joints, Transaire Air-Cooled Heat Exchangers, Shell and Tube Heat Exchangers, Southwest Floating Roof Tanks, Cone Roof Tanks, Pressure Vessels, Field Erection, Columns and Towers, Process Condensers, Custom Fabrication.

YUBA

specialists in process heaters—every size, capacity and duty

YUBA HEAT TRANSFER CORPORATION
Tulsa, Oklahoma

YUBA CONSOLIDATED INDUSTRIES, INC.

Sales Offices in Chicago • Houston • Los Angeles • New York • Pittsburgh • San Francisco

INTERNATIONAL LICENSEES: Birwelco Ltd., Birmingham, England (United Kingdom, British Commonwealth). Heurty Italiana, S.P.A., Milan, Italy. Societe Anonyme Heurty, Paris, France. Societe Anonyme Belge Heurty, Liege, Belgium. Fujinagata Shipbuilding Ltd., Osaka, Japan.

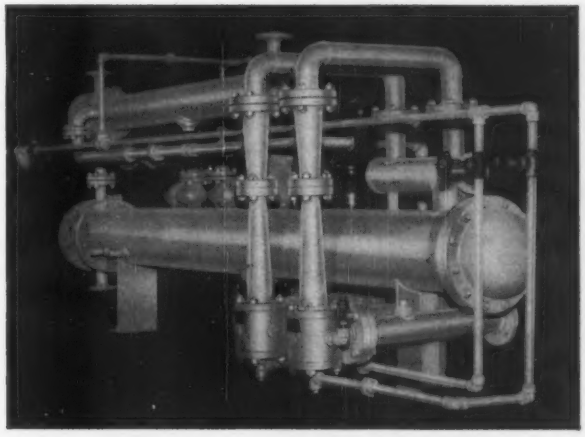
The Bums Rush!

We urge you to apply the same technique to any of your inefficient or outmoded Steam Jet Ejectors

Too bad Andy had to receive such rough treatment; but it's one way to get rid of the undesirable. Perhaps you are operating a group of Steam Jet Ejectors in your plant which should be replaced.

Graham has been the leader in this field for well over a quarter of a century — and we offer you a modern design that means big steam savings plus reliable performance — all developed in one of the best vacuum laboratories in the industry.

Let us solve your present problem by calling in our nearest sales engineer and have him detail the advantages of a truly efficient ejector — the Graham Steam Jet Ejector.



At right: Graham Twin Element Multi-Stage Ejector with Surface Inter and After Condenser

Heliflow Corporation

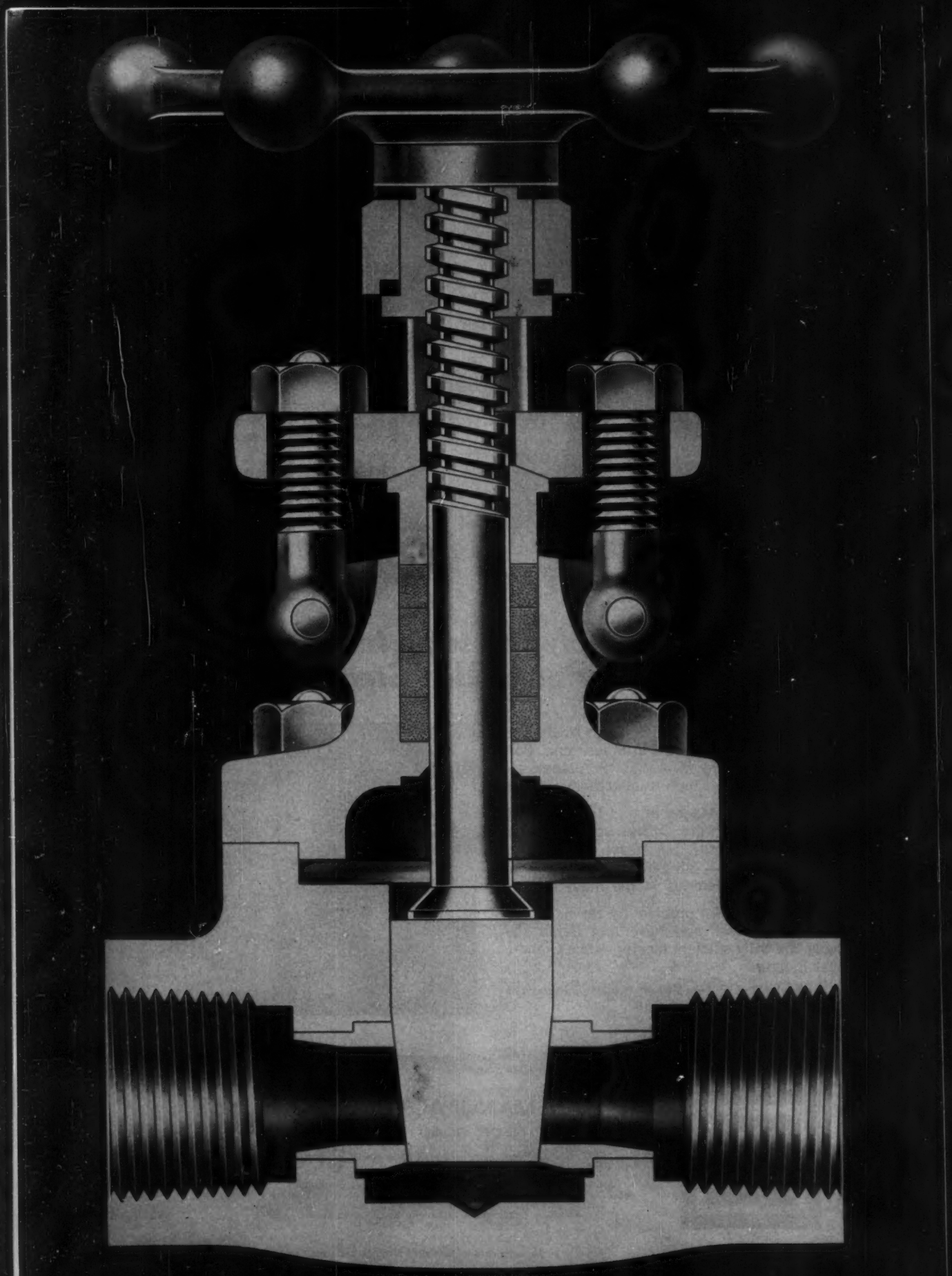
GRAHAM MANUFACTURING CO., INC.

170 GREAT NECK ROAD · GREAT NECK, N. Y.

Offices in principal cities and Canada

Factory: Batavia, New York
Other Graham-Heliflow precision-built products:
Heliflow Heat Exchangers, Monobolt Heat Exchangers, Deaerating Heaters,
Surface and Barometric Condensers, Steam Vacuum Refrigeration,
Panaflow Exchangers, Aquadyne Evaporative Condensers

For more data on advertised products, use cards, last page.



The reputation of a valve is made by the plants it keeps on stream

A valve is often looked upon as a "supply item" until it prevents a major process shutdown and profit loss...

Hancock Steel Valves provide the dependable protection demanded for every process application today and tomorrow. They are available in a wide range of operational pressures and temperatures . . . in an extensive selection of alternate trim, body, and bonnet materials to match the toughest services. They have that extra measure of quality that only a leader knows how to build into a valve... extra quality that extends the operating period between turnarounds and assures efficient, economical processing of petroleum and chemical products.

The valve illustrated at the left is the Hancock Type 950 Steel Gate Valve widely used by the processing and power industries.

For technical assistance in selecting quality Hancock Steel Valves, phone your industrial supply distributor or write for Catalog 200A.

MAXWELL MANNING M&M & MOORE INC. TRADE MARK

HANCOCK Steel Valves

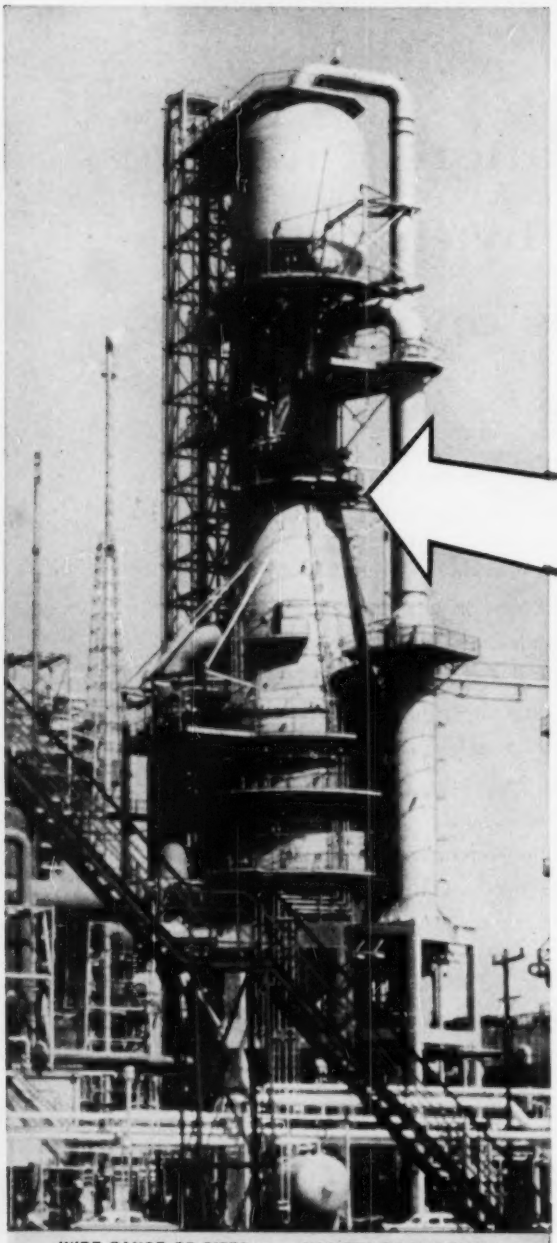
A product of

MANNING, MAXWELL & MOORE, INC.

Valve Division, Watertown, Massachusetts

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S.A., Fribourg, Switzerland

At *CRITICAL* Valve Control Points



WIDE RANGE OF SIZES:

Screwed end ¼" through 3".

Flanged 150# series ½" through 12" — 300# ½" through 8".

Larger sizes on request.

VARIETY OF MATERIALS:

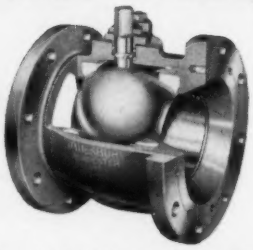
Valves in 303 and 316 Stainless Steel, Alloy 20, Carbon Steel, Bronze, Ductile Iron, Monel, Aluminum and PVC. Interchangeable seats and seals in Teflon, Teflon compounds, Nylon, Buna-N, Neoprene, Hypalon and natural rubbers. Type DZ: Ductile Iron and Carbon Steel, Standard.

Other materials on request.

...You Get Dependable Operation with

jamesbury "Double-Seal"™ BALL VALVES*

*PATENTED.



FIRE SAFE VALVING IN REFINERIES

The Jamesbury "Double-Seal" FIRE SAFE Ball Valve (Type DZ) has been accepted for use in the hydrocarbon industry because of its outstanding performance. In the event of fire — and the loss of the valve's soft seats, secondary metal seats provide effective shut-off of the fluid flow.

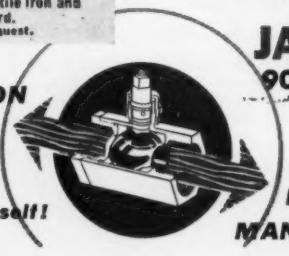
It stands to reason that a valve that performs outstandingly under adverse conditions can be relied on to give trouble-free performance under less severe conditions. That has been one of the big reasons, at least, for the success of Jamesbury "Double-Seal" Ball Valves. Proved dependable at *critical* valve control points, these valves have gone into industrial plants everywhere to control nearly all types of media flow.

There are many exclusive features about the Jamesbury "Double-Seal" Ball Valve which contribute to its excellent performance record. For example, there's Jamesbury's patented lip seal; there are no internal springs; you get leak-tight stem seals; operators are mounted integral with the valve. For further information about Jamesbury "Double-Seal" Ball Valves, contact your nearest stocking distributor — or write us direct.

Ask For Jamesbury Fluid Services Guide

JAMESBURY CORP.
90 New Street, Worcester, Mass.
DISTRIBUTORS IN PRINCIPAL CITIES

QUARTER TURN OPERATION
HIGH FLOW CAPACITY
ZERO LEAKAGE



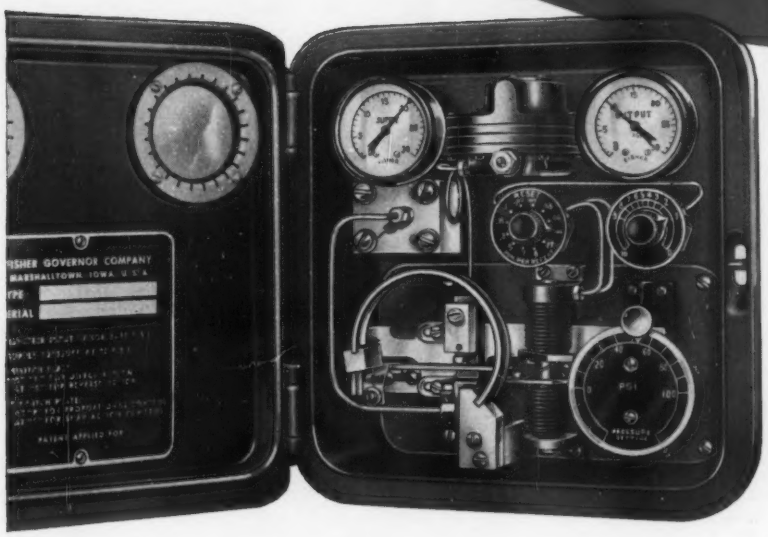
NO LUBRICATION REQUIRED
MINIMUM MAINTENANCE
MANUAL OR POWER OPERATION

As Versatile As Industry Itself!

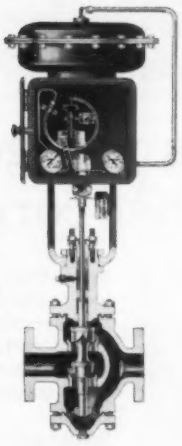
174-I ©Jamesbury Corp. 1961

the Fisher/man shows how to get.....

Accurate pressure control in spite of demand changes



WIZARD II
Pressure Controller



WIZARD I
PRESSURE CONTROLLER

The original Wizard I Pressure Controller is still available for those applications not requiring volume relay or reset features. The simplicity of a self-operated regulator and the accuracy of a pilot or relay operated regulator are found in the Series 4100U. This is, unquestionably, the reason for the continued popularity of the Wizard I series.

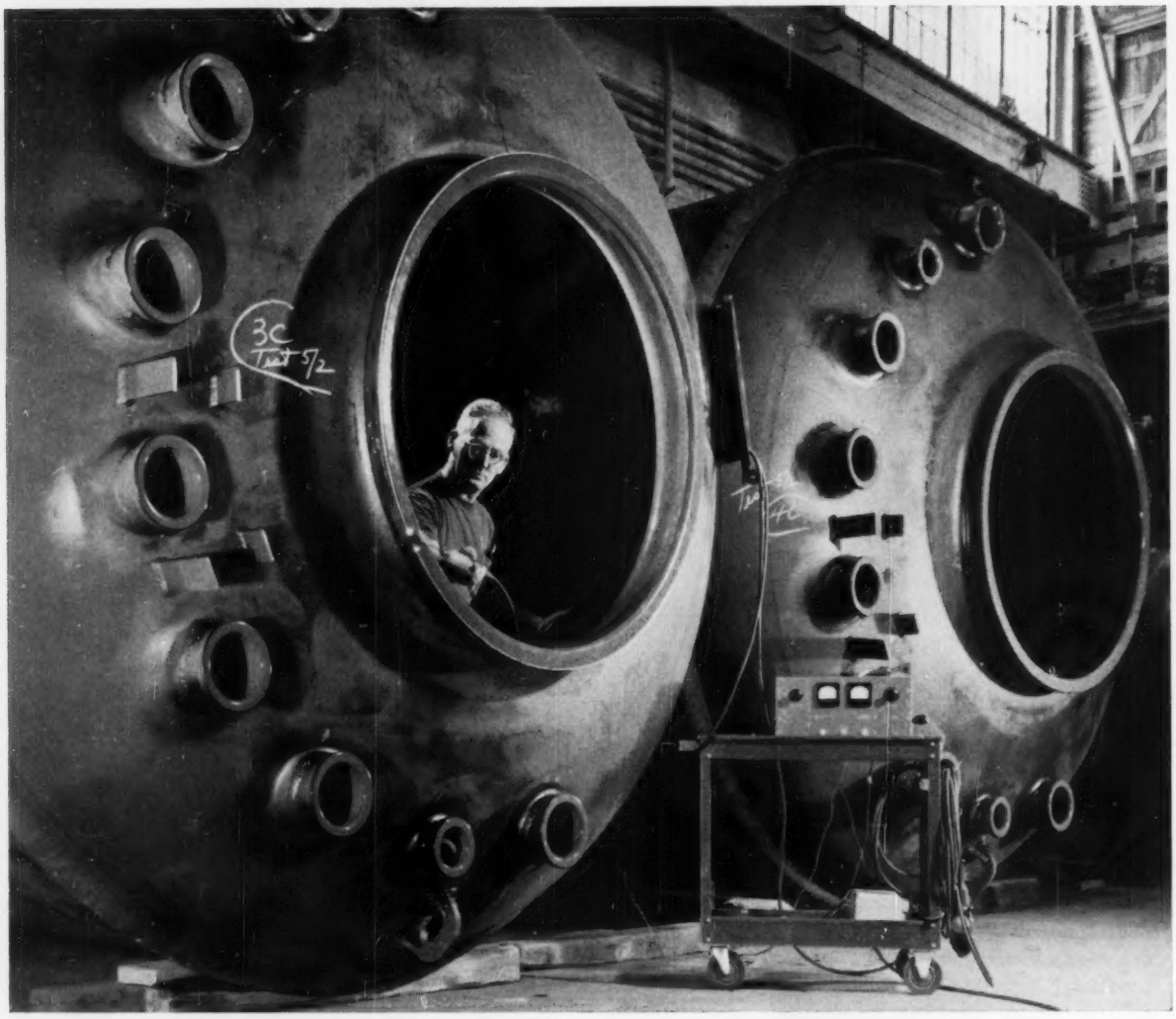
●Faster response to pressure changes provided by volume relay ● Pin-point control made possible by reset feature, adjustable from .005 to 1 minute per repeat ● Wide pressure ranges handled by brass, steel or stainless steel Bourdon tubes for 30 to 15,000 psi, Bellows assemblies for pressures below 30 psi and vacuum ● Easily reversed from direct to reverse action without additional parts ● Universal mounting on a wall, panel, or on yoke of control valve ● Compact construction consists of two sub-assemblies encased in weatherproof die cast aluminum housing, either can be removed without disturbing case mounting. *Write for bulletin No. D-4150B or D-4100 on Wizard I.* Fisher Governor Company, Marshalltown, Iowa. Plants in Woodstock, Ont., Rochester, England. Butterfly Valve Division: Continental Equipment Co., Coraopolis, Pa.

If it flows through pipe anywhere in the world ...chances are it's controlled by.....

FISHER® Controls SINCE 1880

For more data on advertised products, use cards, last page.

FLUIDICS* AT WORK



With Glasteel reactors you get a full-year guarantee against corrosion

This man is electric testing the interior of a Pfaudler® Glasteel reactor. He's making sure that every inch of the inside product-contact surface is completely covered with corrosion-resistant glass.

That's the *glass* in Glasteel. Outside there's *steel* for working strength. Fusing the two together gives you a combination that lets you forget—rather than fight—corrosion.

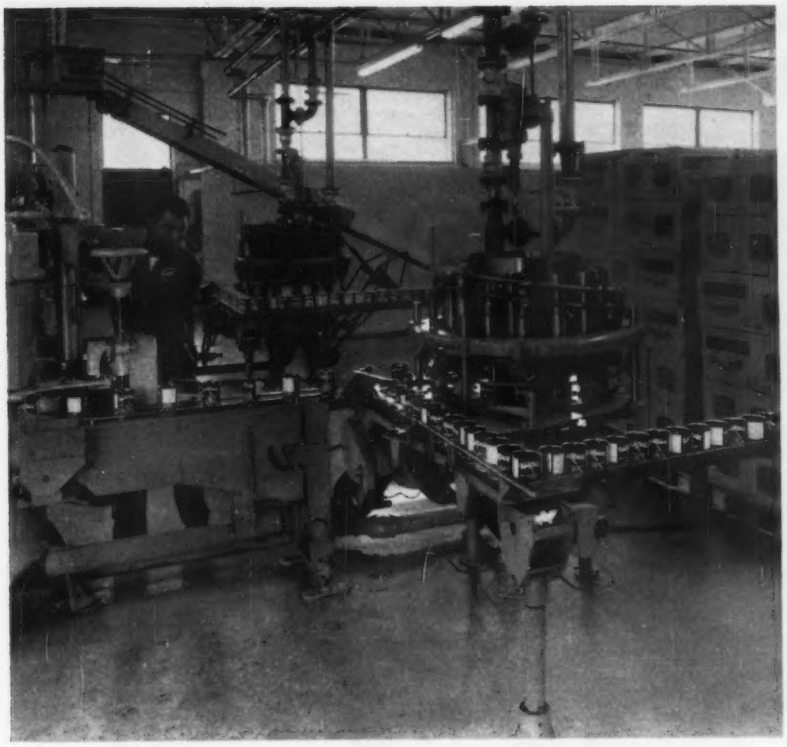
Guaranteed resistant. Glasteel has a natural resistance to corrosive attack. You can use it safely with all solutions of all acids except HF to 212° F (even up to 450° F for certain acid solutions, depending on concentration) and with many alkalies at moderate temperatures. You can do so with complete confidence, since Pfaudler Glasteel equipment is guaranteed against corrosion for a full year after shipment, when used under operating conditions specified and approved. If rendered unusable by chemical attack during this period, Pfaudler will repair or replace it, f.o.b. factory.

Protection plus. That's only part of the story. Glasteel also is inert; it won't influence quality, flavor, color or purity of your products. And its smooth, abrasion-resistant surface resists product buildup. Heat transfer is not impeded by surface fouling by product or corrosion, and cleaning is both quick and complete with a minimum of effort.

Wide choice. You can put these advantages of Glasteel to work in many ways. Select from one-piece, all-welded reactors in standard sizes from 300 to 4,000 gallons—custom designs to 10,000 and even larger. You can also get polymerizers, columns, storage tanks, pumps, pipe, valves and fittings in a range of sizes.

Sound investment. You'll find that Glasteel is actually lower in cost than many of the specialty alloys your processes may require. And Glasteel is your soundest investment when long service life is considered.

More facts. Bulletin 988 spells out the details on Glasteel reactors and Bulletin 932 covers Glasteel polymerizers. For your copies, write to the address shown on the facing page.



Two Pfaudler Rotary Piston Fillers package a variety of viscosities and container sizes at Bardahl Lubricants Inc., Norwood, Mass.

No filler maintenance in two years at Bardahl

No maintenance. No parts replacement. That's the performance record for these Pfaudler RPL-14 Rotary Piston Fillers after *two years* of service.

Bardahl runs this production line with these two fillers handling oils which vary in viscosity from SAE-5W to SAE-50W. Filling rates are as follows: 4-oz. containers at 260 cans per minute, 15-oz. at 225 cans per minute, and quarts at 190 cans per minute.

These are *not* the top operating speeds for the RPL-14, since they are geared to Bardahl's *current* production requirements. Actually, these machines are capable of 350 quarts per minute.

Bardahl tolerates *no* spillage – and none occurs in this installation. One reason why you might consider Pfaudler fillers in your plant. Other reasons?

Simplicity is a key factor. Pfaudler fillers offer a design in which piston and valve can be disassembled without tools in a few minutes.

There are no connecting rods or wrist pins to wear out, no piston rings.

You can quickly clean and visually inspect both filler bowl and valve body. And all gearing is totally enclosed in an oil bath.

Accuracy can be held to $\pm 1/10$ of an ounce for most materials. You can adjust fill accuracy from a single control point, *without* stopping the machine.

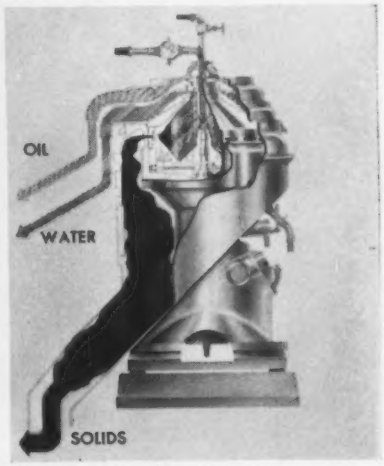
Matched to your needs. The RPL-14 is one of a complete line of fillers from Pfaudler, each designed to meet specific oil-packaging requirements. For example, the RPL-36 can handle as many as 800 quarts per minute.

More information. Bulletins No. 964 and No. 878 give specs on the Pfaudler line of fillers for oil packaging. Write for copies to the address shown on this page.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

How to squeeze more profit out of tank-bottom sludge

Here's a centrifuge that can really add measurably to what you recover from tank bottoms.



With a Pfaudler Titan Superjector you get a 3-way split of oil-water-solids simultaneously in a single pass.

With this Titan Superjector you can efficiently separate oil-water-solids simultaneously, *in a single pass*. You have a settling power up to 7500 times gravity, much more force than you get with most continuous centrifuges.

Equally important, sludge discharge is through slots—*not* nozzles. These slots are $3/8$ inch by 5 inches and handle drier, more compacted sludges with particles up to $1/8$ inch in diameter. There is no down time for cleaning bowl or clogged nozzles. Adjusting the hydraulic controls accommodates varying solids content of the feed and desired sludge dryness.

We'll run tests in our Engineering Test Center or *in your plant* with a portable production unit. More details found in Bulletin 946. Write for your copy.

New Glasteel bulletin

All the pertinent data on Glasteel, the *material of construction*, have now been brought together in a single full-color brochure.

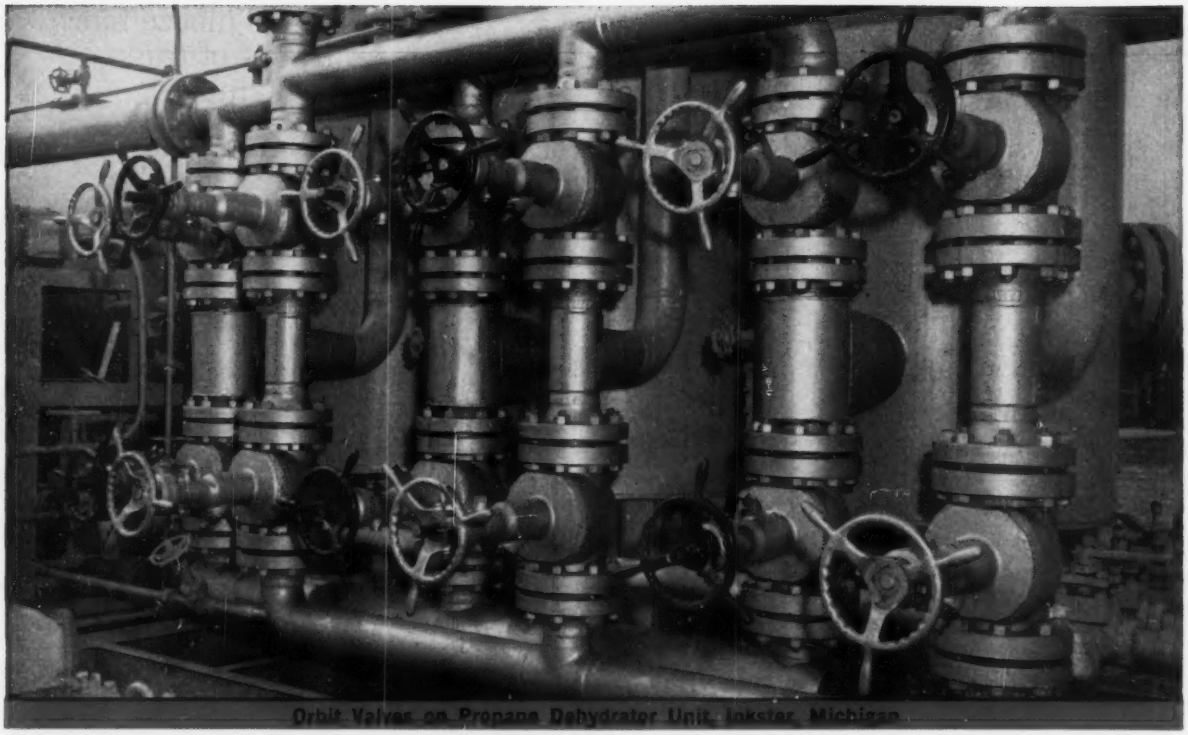
It's Bulletin 985, and in its 20 pages you'll find 16 pages of *technical data* on thermal shock, operating temperatures, specifications, and corrosion resistance. Write for your free copy today.

Please address all inquiries to our Pfaudler Division, Dept. PR-101, Rochester 3, New York.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

For more data on advertised products, use cards, last page.



Orbit Valves on Propane Dehydrator Unit, Inkster, Michigan

ORBIT VALVES ARE IMPORTANT PART OF EFFICIENT DEHYDRATION UNIT

HYDROCARBONS, AMMONIA, CARBON DIOXIDE, ETHYLENE, HELIUM, HYDROGEN, NITROGEN, NATURAL GAS — ALL REQUIRE DRYING UNDER CERTAIN CONDITIONS. ORBIT FORGED STEEL ASA CLASS VALVES MEET THE TOUGH CONDITIONS FOR DEHYDRATOR SERVICE.

The efficient operation of a dehydration unit is dependent upon the proper selection of all components. Here valves are required to provide absolute shut-off under such conditions as cyclic operation, high differential pressures, and wide temperature ranges. In addition, valves must be free from stem leaks, be free from sticking or freezing, and be free from dust build-up on seating surfaces.

Selected to handle this tough job — Orbit Full Opening Forged Steel Valves. These valves provide full flow, friction-free resilient seating and there is no chance for line build-up or trapping of solids or line fluids because there are no body cavities. Particles of drying agent cannot get between seating surfaces because valve is self-cleaning and dust carryover is swept through valve by gas streams.

The maximum rated working temperature for Orbit's standard line of ASA class valves has been increased from 250° Fahr. to **400° Fahr.** Prices for these valves remain the same.

IN ADDITION Orbit ASA class valves are now available for **450° Fahr.** Maximum rated working temperatures in 150-300-400-600 lb. Class. Write us for prices.

Learn how Orbit Valves can help your installation by writing to our Industrial Sales Department.

ORBIT VALVE COMPANY

P. O. BOX 699

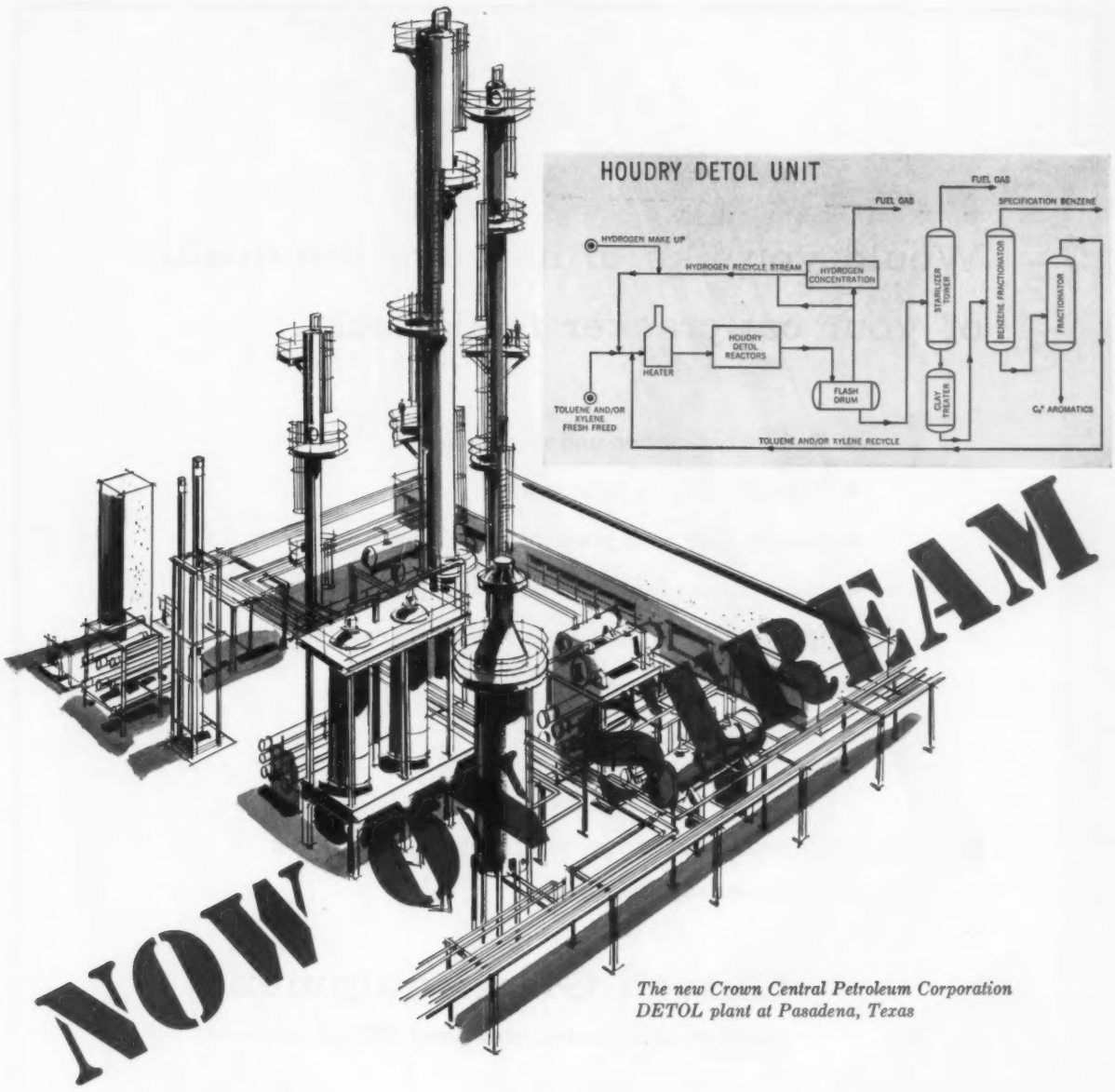
TULSA, OKLAHOMA

PHONE LUther 4-4761

TWX TU 925

Orbit ASA Class Valves are available through your favorite Supply Store

ORBIT VALVES ®



The new Crown Central Petroleum Corporation DETOL plant at Pasadena, Texas

Crown Central 17-million gal/yr benzene plant using DETOL Process now on stream

The Houdry DETOL Process is now producing the expected high yields of better than nitration grade benzene by the hydrodealkylation of toluene feedstock for Crown Central Petroleum Corporation.

Start-up and operation of this plant have demonstrated its simplicity and ease of control.

The Houdry catalyst specifically developed for the DETOL process permits use of relatively moderate temperatures for high conversion of toluene per pass.

Information on the Houdry DETOL process furnished on request.

***HOUDRY**
PROCESS CORPORATION
1528 Walnut Street, Philadelphia 2, Pa.
**Houdry means Progress . . . through Catalysis*

For more data on advertised products, use cards, last page.

Would you like to improve the quality of your cat cracker feed stock...

- Reduce con-carbon and metal content
- Improve color to light straw
- Reduce flash zone pressure and temperature
- Maximize cat feed stock and make penetration asphalt
- Back out crude and up grade No. 6 to cat feed stock
- Reduce cat gas make
- Increase capacity

For additional particulars and details, contact a Glitsch representative about

Glitsch-Grid Equipment

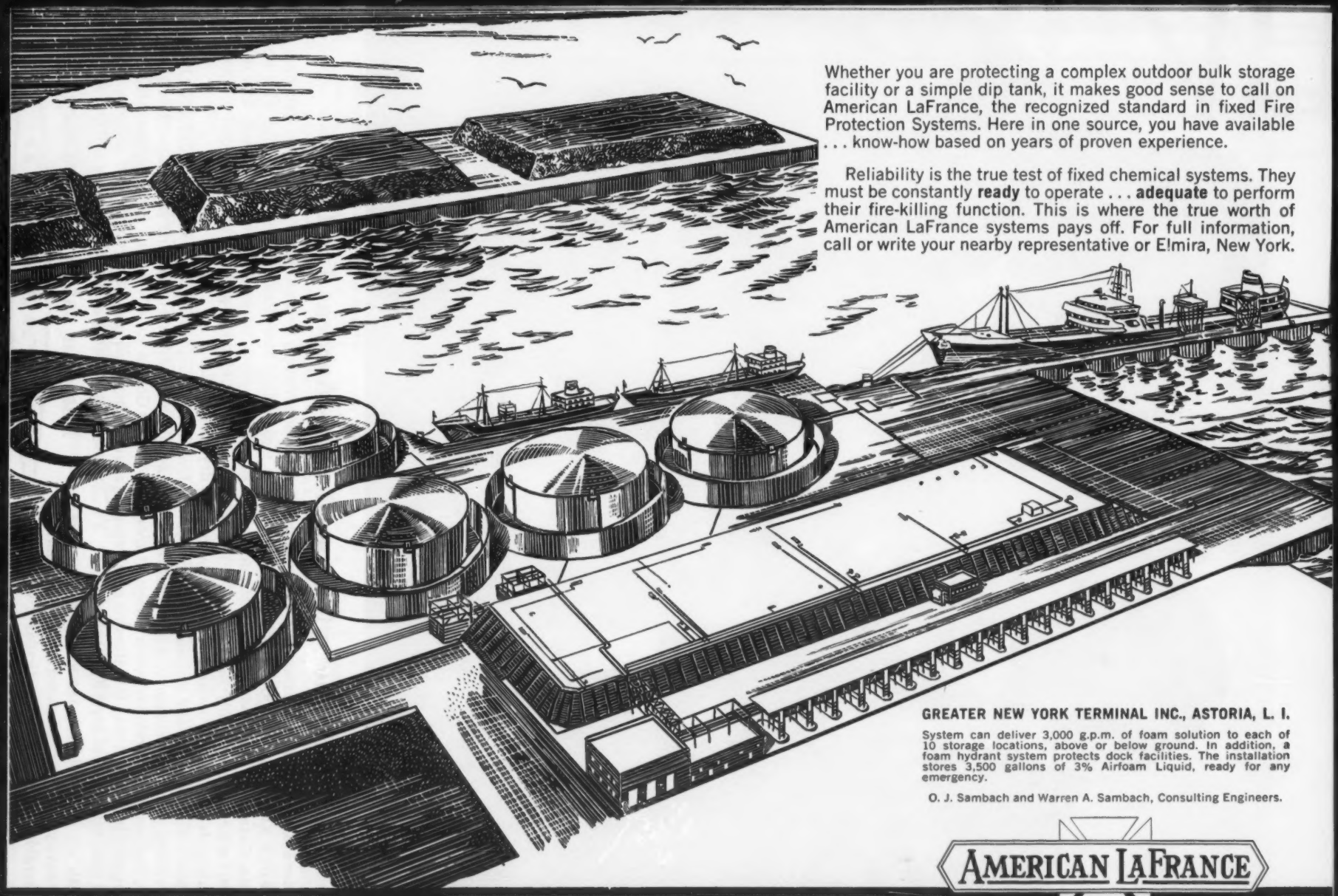
***another* plus-quality designed Glitsch product**

Glitsch
SINGLE ENGINEERING RESPONSIBILITY

Fritz W. Glitsch and Sons, Inc.

General Offices and Manufacturing Plant: 4900 Singleton Boulevard, Dallas

Houston • Tulsa • Baton Rouge • Cleveland • New York City • Los Angeles • Charleston, W. Va. • Chicago • Uxbridge, Canada Monterrey, Mexico



Whether you are protecting a complex outdoor bulk storage facility or a simple dip tank, it makes good sense to call on American LaFrance, the recognized standard in fixed Fire Protection Systems. Here in one source, you have available . . . know-how based on years of proven experience.

Reliability is the true test of fixed chemical systems. They must be constantly **ready** to operate . . . **adequate** to perform their fire-killing function. This is where the true worth of American LaFrance systems pays off. For full information, call or write your nearby representative or Elmira, New York.

GREATER NEW YORK TERMINAL INC., ASTORIA, L. I.

System can deliver 3,000 g.p.m. of foam solution to each of 10 storage locations, above or below ground. In addition, a foam hydrant system protects dock facilities. The installation stores 3,500 gallons of 3% Airfoam Liquid, ready for any emergency.

O. J. Sambach and Warren A. Sambach, Consulting Engineers.

• FIRE PROTECTION WHERE AND WHEN IT COUNTS •

AMERICAN LAFRANCE

A DIVISION OF STERLING PRECISION CORPORATION

ELMIRA, N. Y.

• The *TRUSTED* Name in Fire Protection Equipment •

• EXTINGUISHERS • APPARATUS • HOSE AND NOZZLES • CHEMICAL SYSTEMS •

LaFrance Export Corporation
Elmira, N. Y.

LaFrance Fire Engine and Foamite Ltd.
Toronto 18, Ont.

Photographed at DX Sunray Oil Company, (Tulsa Refinery)

For a higher yield per dollar—Aerocat Triple A

Why more and more refineries are increasing efficiency and cutting costs with this 25% Alumina Catalyst. AEROCAT TRIPLE A® Cracking Catalyst, the first commercially successful 25% alumina catalyst, is still setting records. Its combination of extremely high activity and unusual stability provide premium cracking efficiency, high equilibrium activity, increased conversion at lower temperatures, or (compared to conventional, low alumina catalysts) reduced catalyst usage at severity levels.

Yet, with all its efficiency, AEROCAT TRIPLE A can actually save you money, compared to other synthetics of comparable performance—particularly where low catalyst turnover is possible. It yields *more* gasoline; it measurably increases octane rating, and with no increase in stack losses of the catalyst itself. The increased output takes place at the expense of a lower dry gas yield.

Isn't it time you investigated what AEROCAT TRIPLE A can do for *you?* Your Cyanamid salesman—"The Man with the Golden Rule"—will be glad to cooperate, for sharing his skill and experience with refiners is a most important part of his job. Why not call him *now?*

Basic in catalyst chemistry

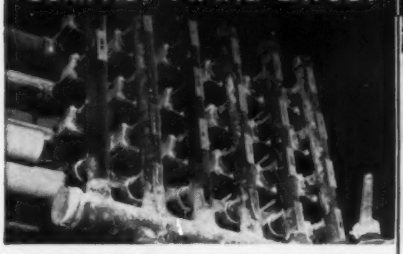
CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, New York 20, New York

ILLUSTRATED:
1" SIZE
SIZE RANGE:
¼" TO 6"

THE ECON-O-MISER BALL VALVE

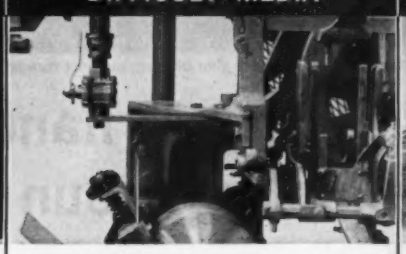
COMPACT PIPING LAYOUT



Here are 19 Econ-O-Miser Ball Valves compactly installed on this paint blending manifold. Note the absence of unions . . . this valve is both a valve and a union! The Econ-O-Miser is smaller, easier to install . . . just right for modern piping layouts, where equipment must fit into tight areas.

Let us show you . . . in your own plant! Write us about your limited space problems!

DIFFICULT MEDIA



The Econ-O-Miser Ball Valve successfully controls the flow of cold glue with a viscosity of molasses, on the WORLD Tandem Labeler manufactured by Economic Machinery Co. Clean wiping action, positive leakproof shut-off, and smooth round flow, make the Econ-O-Miser ideal for handling difficult media.

Let us show you . . . in your own plant! Write us about your media problems!

TROUBLE-FREE OPERATION

Outdoor propane and butane storage tanks in remote field processing plants require dependable positive shut-off valves on bleed lines. The unique features of the Econ-O-Miser Ball Valve provided the practical answer . . . no lubrication . . . no metal-to-metal contact . . . quick visual ON-OFF indication . . . trouble-free service.

Let us show you . . . on your outdoor applications! Write us about your valve maintenance problems!

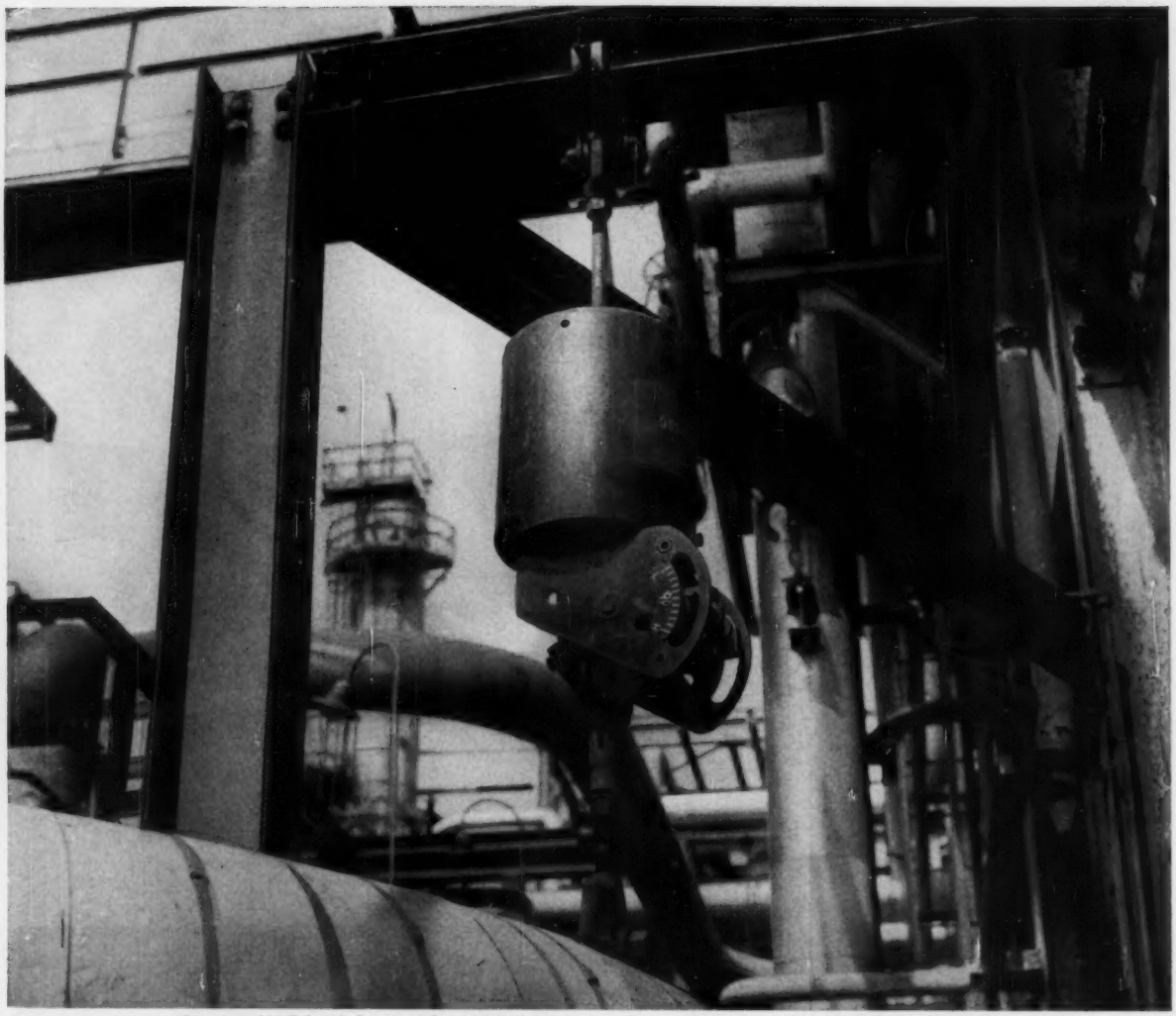
COMPARE . . . THE ECON-O-MISER BALL VALVE

NO UNION NECESSARY

WORCESTER VALVE CO., INC.

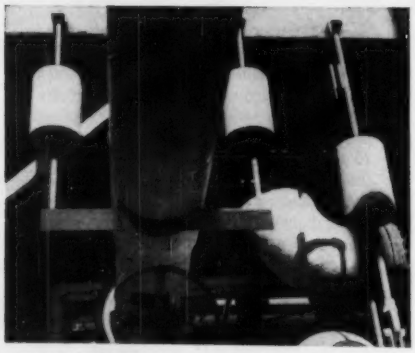
16 PARKER STREET, WORCESTER, MASS.

For more data on advertised products, use cards, last page.



Space-saving Grinnell Constant Support Hangers give uniform support throughout all positions of travel

Grinnell Pipe Hangers handle the high temperature piping at Sun Oil refinery



Pre-compressed Grinnell Variable Spring Hangers provide minimum variation in supporting force

At Sun Oil Company's Marcus Hook, Pennsylvania refinery, pipe lines often heat up over 500°F! When pipe lines get this hot, thermal movements become a big problem. The answer: *Grinnell Hangers.*

Grinnell Constant Support Hangers are used where reactive forces at terminal points — and stresses within the pipe resulting from weight transfer — must be minimized.

Grinnell Variable Springs are used where pipe lines, subject to vertical movement, can absorb controlled additive forces and stresses resulting from weight transfer.

A third type of Grinnell device — Grinnell Sway Brace — is available for preventing abnormal horizontal movement or vibration.

For a complete line of engineered pipe hangers and supports . . . for skilled assistance right from the design stage . . . for experienced field engineering service . . . call on Grinnell Co., Providence 1, R. I.

GRINNELL AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Pipe Fittings, Valves, Pipe Hangers, Prefabricated Piping, Unit Heaters and Piping Specialties

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symbol of modern valve design Announcing Continental's new 8", 10" and 12" Teflon-sleeved, non-lubricated plug valves. Now, for the first time, Tufline's proven design features ....pre-stressed pure Teflon® sleeve, sculptured body bore, bubble tight performance....can be obtained for larger piping. Advantages: quick, easy operation [manual, automatic], no flow pockets. 150# rated for light gases to heavy slurries and corrosive services. Also available in bottom-entry 3-way design and choice of metals. Write Continental Manufacturing Co., 230 Park Ave., NY 17, NY

TUFLiNE valves

Maintain maximum throughput with Texaco Rust Inhibitors

Texaco Rust Inhibitors keep pipelines completely free of rust and scale. One injection point protects 1,200 miles of line.

Actual in-service tests prove that even after three years of continuous use, pipelines protected by Texaco Rust Inhibitors showed absolutely no signs of corrosion. Only one injection point was needed to protect up to 1,200 miles of line.

Will not react with metals. TRI-182 plates out in an invisible film that protects all metal surfaces through which the inhibited product passes. Oil-soluble and polar by nature, TRI-182 does not react chemically with metals. Neither will it adversely affect the performance of fuels, anti-oxidants, scavengers, inhibitors, dyes, and TEL used in petroleum products.

Protects refinery tankage and tankers. TRI-182 works equally well in protecting refinery tankage and tankers against corrosion. Addition of Inhibitor into refinery blending tankage protects both tankage and line. Flotation method of application is recommended for tankers.

For specifications and details on application, write for Technical Bulletin TRI-182. Address Dept. OGP.

Texaco Inc., *Petrochemical Sales Division*, 135 East 42nd Street, New York 17, N. Y. or 332 South Michigan Ave., Chicago 4, Ill. Dept. PF

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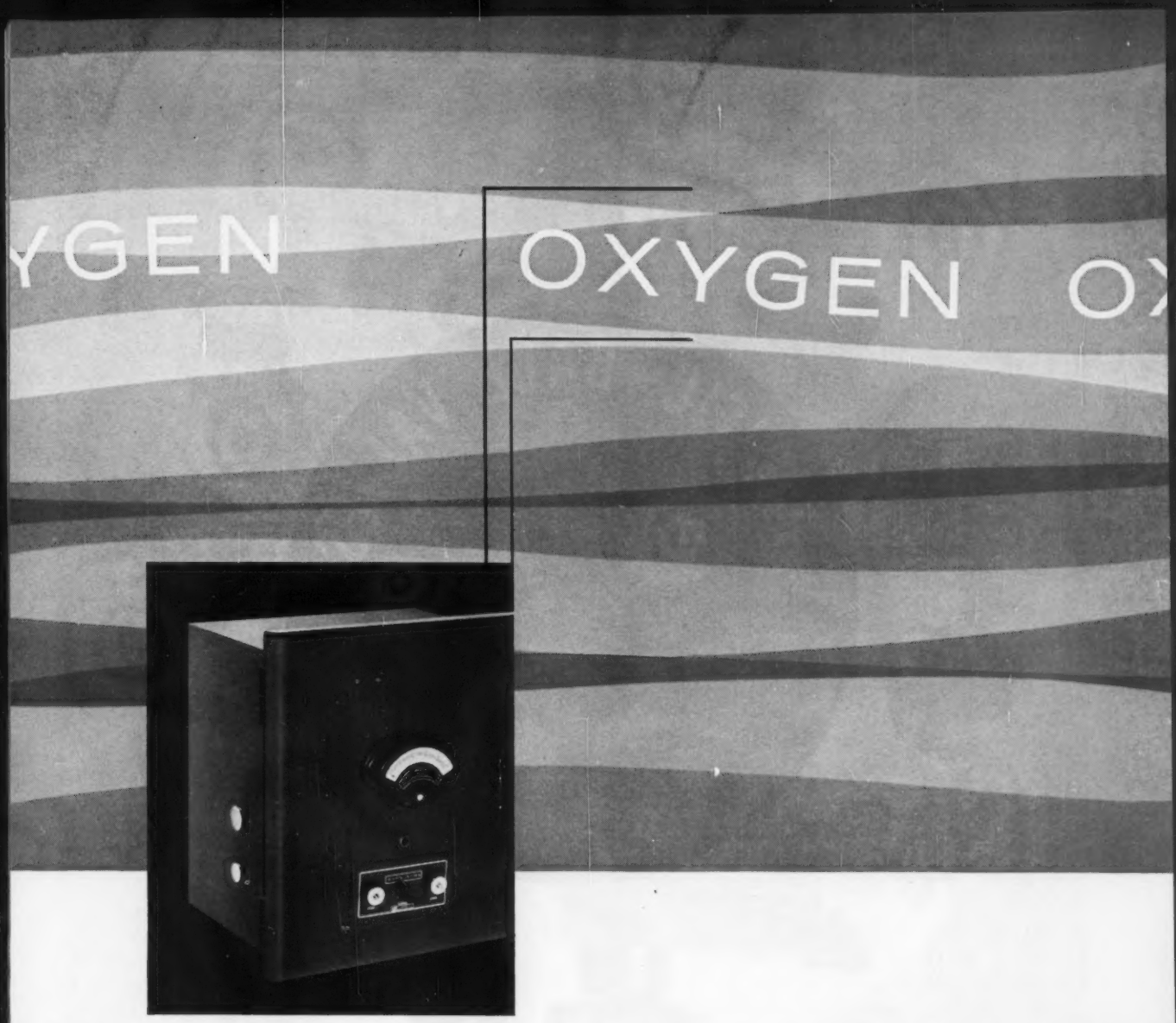

Wherever continuous oxygen measurement must be accurate...Beckman has the right answer!

Beckman has the instrument that's made to order for your oxygen measurement application. For Beckman has the most complete line of Oxygen Analyzers from which to choose. Measure 0_2 in ranges from parts per million to 100%–with sample handling equipment to meet your most exacting requirements.

Your Beckman Sales Engineer has the answers to your questions on process Oxygen Analyzers. Contact him for complete details, or write for Data File 25-10-08.

MODEL F-3 operates on a paramagnetic principle found only in Beckman® Oxygen Analyzers. Assures fast response, great sensitivity, and simple operation. And the F-3 has dual ranges that are directly linear. Read oxygen concentration from a self-contained meter or a standard potentiometric recorder. The Model F-3 is ideal for wide ranges of analyses–from 0-1% to 0-100%–and suppressed ranges are available, too.

MODEL G-2 also utilizes the paramagnetic principle of operation. Supplied with potentiometric recorder modified to provide automatic instrument zeroing for critical analyses. The Model G-2 is ideal for narrow and highly suppressed ranges–0-1000 ppm to 99-100%.

MODEL 80 TRACE OXYGEN ANALYZER operates on the electrolytic cell principle. This dual range instrument provides highly accurate linear measurement in the parts per million ranges. The Model 80 is particularly suited for monitoring gases in which oxygen content must be extremely low–from 0-5 to 0-500 ppm.

ALSO AVAILABLE AND READY TO SERVE . . . a complete line of portable laboratory oxygen analyzers.

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SCIENTIFIC AND PROCESS INSTRUMENTS DIVISION

Fullerton, California

PACIFIC, the *PACESETTER* Offers a well rounded out line of Ball Valves and Accessories—Ball Valves to meet nearly every application!

PACIFIC offers screwed end valves—from ¼″ to 2″; 150 lb. flanged end valves—from ½″ thru 14″; full opening ball valves—from ¼″ to 2″, with screwed ends and 6″ thru 12″, with flanged ends; High pressure ball valves for gas service, up to as high as 6000 lbs.—in sizes ⅛″ thru 1″; "FireSafe" ball valves; Block & Bleed ball valves; High-Pressure ball valves—from ¼″ to 2″ (W.O.G. up to 2500 lbs.); a line of ratchet and spring return valves; a line of 150 lb. and 300 lb. flanged, 3-Way ball valves—from 1½″ to 8″ and; a line of screwed end, 3-Way ball valves—from ½″ to 2″.

PACIFIC Ball Valves are available in the following standard materials: Cast Iron, Ductile Iron, Bronze, Aluminum, Carbon Steel, CF8 (304), CF8M (316), Alloy 20, and Monel...in seal materials: Buna-N, Neoprene, Viton, Teflon, Kel-F, Nylon, Delrin and Polyethylene.

PACIFIC Ball Valves can be supplied with: air cylinder operators, Electric motor operators, Worm-gear operators or any of the commercially available operators.

Let a PACIFIC representative show you how these Ball Valves can meet your requirements and give you unbelievable performance.

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The first ALL-NEW line of special purpose enclosures in 25 years. (NEMA 4, 5, 7 and 9)

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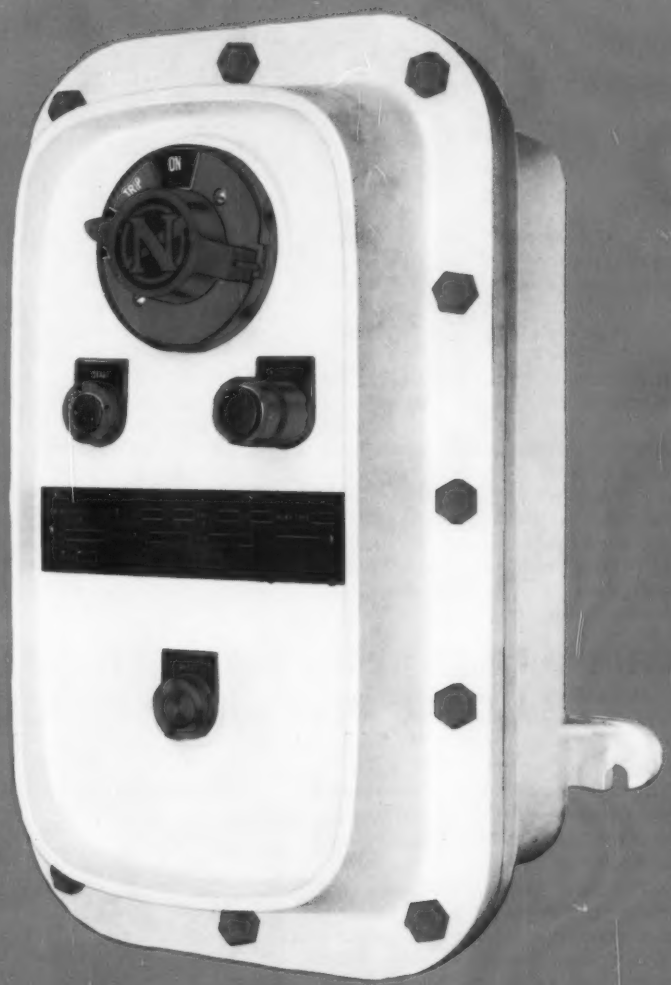
NEW PLUG-IN COMPONENTS

NEW FUNCTIONAL APPEARANCE

NEW QUICK-OPEN COVER



NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

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NELSON ANNOUNCES COMPLETE NEW LINE STARTER & CIRCUIT BREAKER ENCLOSURES

A completely re-designed line of starter and circuit breaker enclosures for hazardous and special purpose applications is now being produced by Nelson Electric Manufacturing Company, Tulsa.

In making the announcement, H. A. Norberg, president of the firm, said "Although we have been an important producer and a leading supplier of electrical equipment for hazardous locations for over twenty years, we have not been satisfied with the approach to such equipment — neither ours nor our competitors.

H. A. Norberg

"To find the solution, we sent our marketing team to customers to discuss their problems. After this research was behind us, we engaged Mr. Wayne Porter — an outstanding industrial designer — who established the basic appearance of our new line.

"When we arrived at what was thought to be the final product, we built prototypes and took them to major users of this kind of equipment — over 100 design and maintenance engineers and purchasing people in the petroleum, petro-chemical, steel, milling and other industries. The men we talked with were most helpful. They spent hours with our marketing people, going over the new equipment. They told us what they liked, and what they disliked.

"After the survey, changes were made to incorporate most of the ideas brought out by interview. Now we have it. We call it the *White Line*. We feel sure it is the shape of things to come in electrical control equipment. And we invite you to become familiar with it at your earliest opportunity."

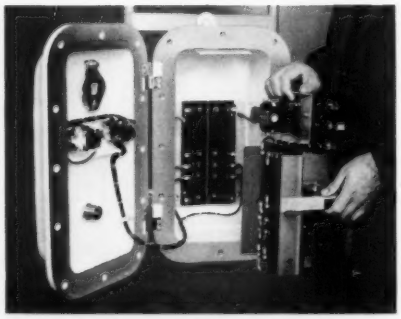
Nelson's new White Line Circuit Breaker includes enclosures for circuit breakers up to 1,000 ampere size. Notice the compact, rectangular design.

ELECTROL PLUG-IN COMBINATION STARTER IS STAR OF WHITE LINE

Prominent among the many advances found in Nelson's *White Line* is a new concept for hazardous area starters— the *Electrol*. These new starters were designed to satisfy modern requirements in today's automated refineries and chemical plants.

The new *Electrol* features complete plug-in components to make change-out a matter of minutes rather than hours. Critical processes are back on the line fast. Line, load and control wiring are all disconnected when the interior is removed. Both starter and circuit breaker, with optional extras such as control transformer, are pan mounted and are removed or inserted without the use of tools. The *Electrol* design — which requires from 23% to 50% less mounting space than competitive makes — includes starters through sizes 4.

For those who desire conventional mounting, non plug-in interiors are available at competitive prices. Sizes 5 and larger are available only in non plug-in design.



Plug-in feature of Electrol combination starter features line, load and control plug-in. Enclosures can be opened, plug-in components removed and replaced, enclosure closed and returned to service within three minutes.

NEW WHITE LINE BY NELSON FEATURES DESIGN CHANGES

One of the most striking changes is the white color of the enclosures. White is the best heat reflective color. This helps keep the interior cooler; in fact, 20° cooler by test — which results in less nuisance tripping and more accurate selection of overload heaters.

The white paint used has a specially selected vinyl base for maximum resistance to corrosion and abrasion. The use of white will eliminate the need of repainting enclosures after installation since the white blends with any color scheme.

The shape of the new *White Line* enclosures is both functional and eye appealing. Fewer flange bolts are required because the enclosure is tailored to the equipment. The bolts are stainless steel, captive type which eliminates lost bolts and fumbling around. In addition, they are the quick-thread type — only one-and-one-half turns are necessary for removal. The raised ridge on the cover is more than decoration; it strengthens the cover and provides a protective recess for hand controls.

Covers on the new *White Line* are hinged to the box, except on the very smallest breakers. This makes servicing simpler and faster since the cover swings out of the way. There is nothing to interfere with complete access to the interior, no heavy pieces to lift and hold in place, and no way to drop the cover on the ground.

Designed to use every major brand of starter and circuit breaker, the *White Line* allows customers to keep spare parts inventory at a minimum, because they may specify the brand on which they have standardized.

Mounting of the new units is simple — due to a new 3-point mounting. This means the enclosure is always solid with no stress when mounted on uneven surfaces. The unit is easier to install, too. After installing the top mounting bolt, the enclosure may be hung on it leaving both hands free to put the remainder of the bolts in place. All *White Line* cast enclosures are available in either iron or aluminum.

In addition to the new starter and circuit breaker enclosures, the *White Line* also includes cast iron and aluminum junction boxes, lighting panels, control stations and power distribution panels.

DELIVERY: Often a challenge!

Delivering this 165 foot, 135 ton fractionating tower on schedule often had its moments.

Built by Sun Ship for a petrochemical company's gas-processing operations, this giant tower presented quite a challenge enroute. Passing through narrow bridges with mere inches to spare, became routine.

But we're used to handling unusual situations. We specialize in designing and building to the most unique requirements. You can be sure of precision engineering and construction on any type of project, from intricate equipment to cargo ships.

Our diversification applies to delivery also. Besides our experience with railroads, being on the hub of the Delaware River makes us a natural for shipment by water.

BUILDING FOR LAND: Pressure Vessels • Fractionating Towers
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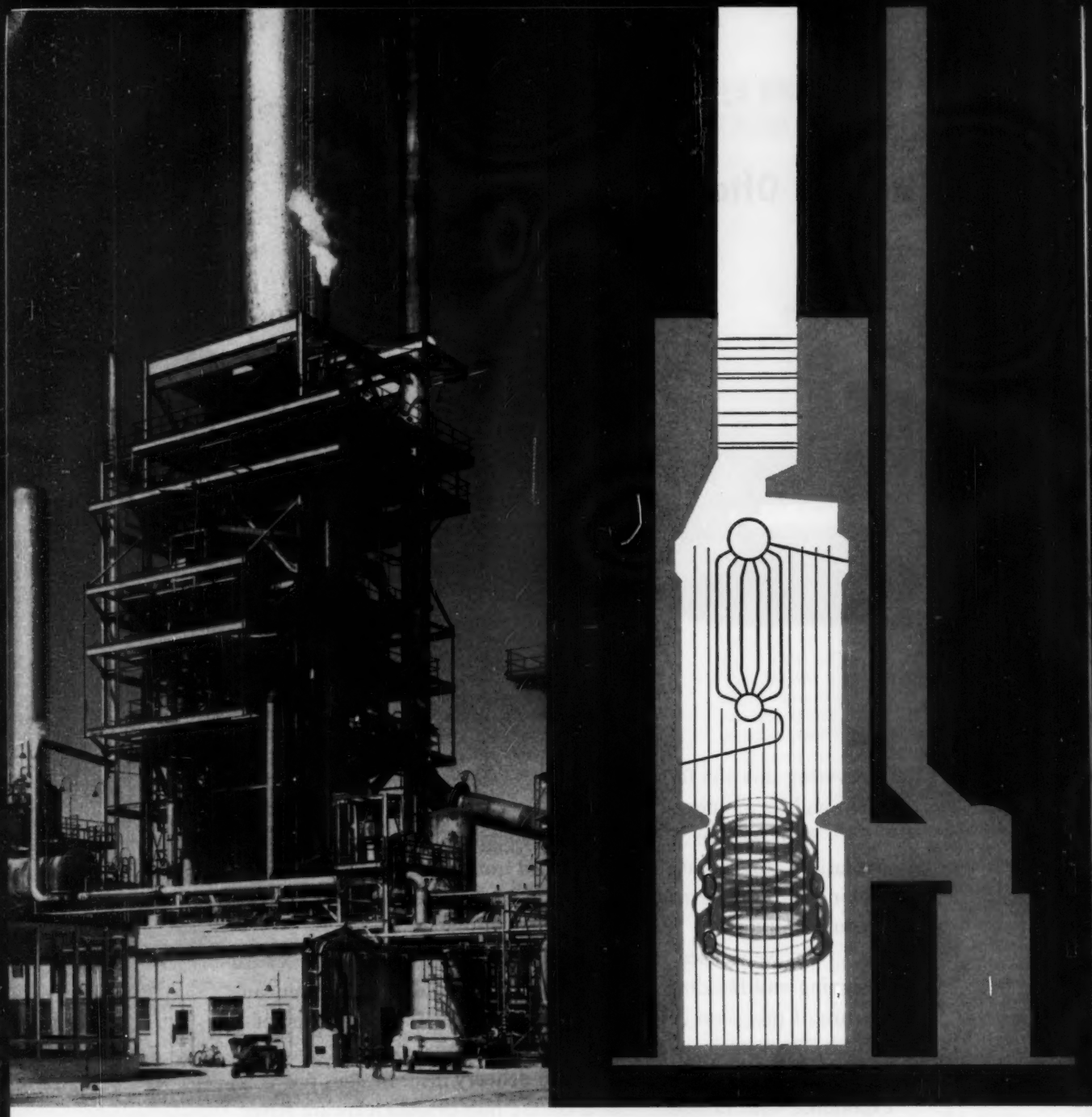

This B&W CO* boiler generates refinery steam economically, easily and safely...by burning waste gas!

Babcock & Wilcox CO* boilers have three characteristics that make them ideal for refinery use:

1. *Minimum use of auxiliary fuel.* Three quarters of the heat energy comes from waste gas, one quarter from supplementary gas firing. (In some cases, supplementary firing is as low as 10%.) The CO boiler's circular design assures extreme turbulence, stable firing and complete combustion.

2. *Ability to handle upsets.* Variations in the regenerator gas do not cause difficulties. Upsets, such as water introduced in the regenerator for smoother after burning, are easily taken in stride.

3. *Safe.* The boiler is safe under all conditions. There are no gas pocket areas. Gas flow is upward, smooth, and direct.

Available in 25,000 to 500,000 lb/hr steam capacities, the CO boiler can be used in existing refineries or new plants. For information write: The Babcock & Wilcox Company, Boiler Division, Barberton, Ohio.

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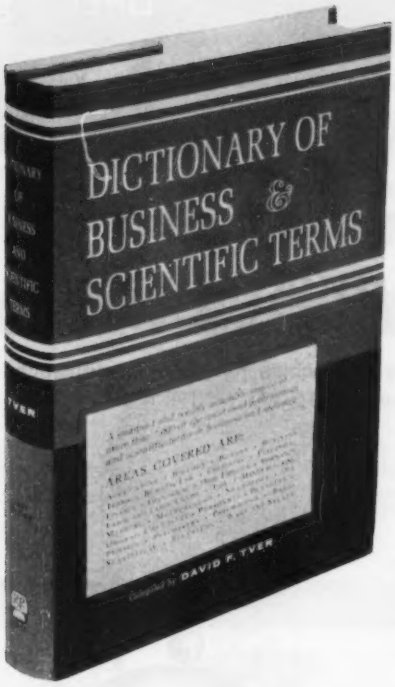

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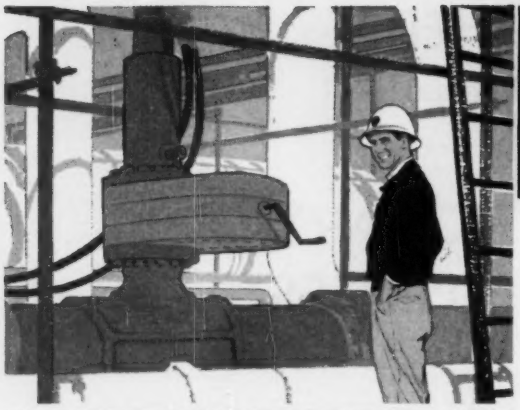
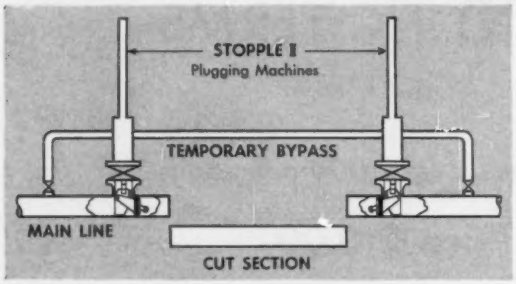
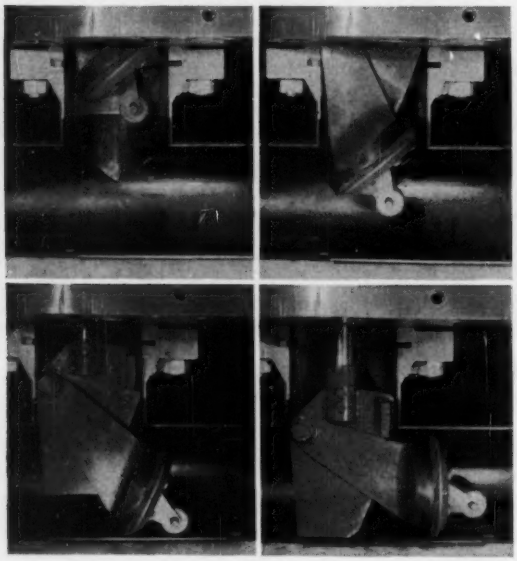


NEWS FROM DOWN THE LINE!



❶ "This method of plugging a line and bypassing the flow has been used extensively in plant and field operations with WMSon tapping and STOPPLE equipment. Many costly shutdowns have been avoided. Now, WMSon engineers have re-designed and improved the STOPPLE Plugging Machine. Result . . . the all new STOPPLE II . . . offering hydraulic operation, improved, simplified construction, and economy—**real** economy!"

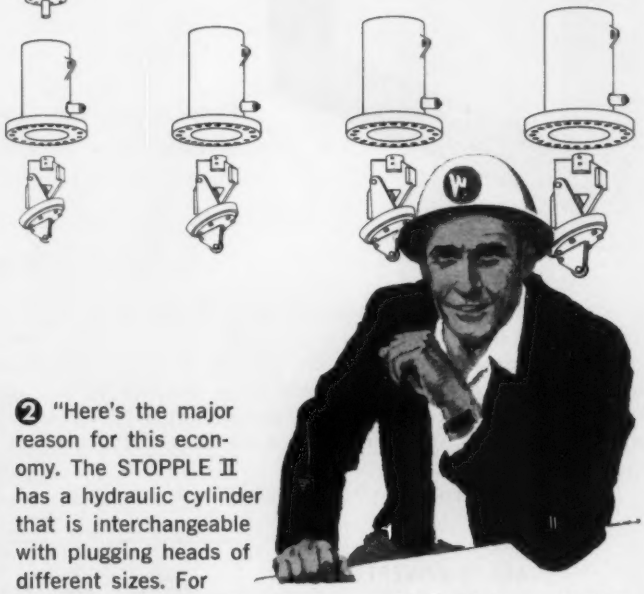


❸ "Here's how STOPPLE II works. After the tap is made, the STOPPLE II is mounted on a WMSon SANDWICH Tapping Valve, and the plugging head is lowered into the line, stopping the flow completely. New single link construction of the plugging head offers built-in simplicity . . . and strength for high pressure plugging."

NEW economy
NEW improved design
NEW interchangeable plugging heads . . .

WMSON'S ALL NEW STOPPLE® II

Plugging Machine for piping modification or repair WITHOUT SHUTDOWN!



❷ "Here's the major reason for this economy. The STOPPLE II has a hydraulic cylinder that is interchangeable with plugging heads of different sizes. For example, one hydraulic cylinder can be used on a 14", 16", 18" or 20" line by using it in combination with a plugging head and housing of the proper size."

•

WMSon STOPPLE II with hydraulic operation is available in sizes 8"–30". The 4" and 6" units are hand operated. Single link is standard in all sizes. Write for additional information and specifications: Write Dept. G for Bulletin A-513.

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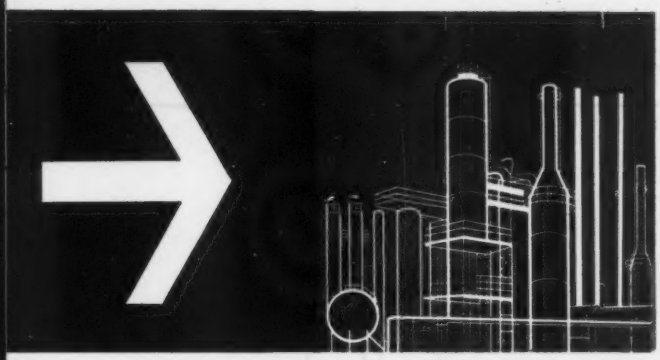
REPRESENTATIVES AROUND THE WORLD



Send for New data on GROVE Reducing and Back Pressure Regulators

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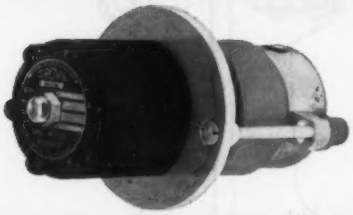

GROVE SMALL VOLUME REGULATORS
Small, hand adjusted, panel mounted models 16 and M6300 class for reducing and back pressure service. Feature nylon diaphragms or Kel-F on special order. 18/8 stainless for all parts in the flow stream.

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Miniaturized, extremely accurate. Reducing model 94W features nitrile rubber diaphragm, Viton diaphragms on special order. Back pressure Model 90 has nitrile rubber diaphragm, 91 features Teflon diaphragm. Aluminum alloys or 18/8 stainless.

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GROVE POWREACTOR® REGULATORS
Self-contained, direct acting reducing regulators. Type W, externally dome loaded. Proved in critical aerospace propellant handling systems. Wide range of body and diaphragm materials.

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( ) Grove #16 and M6300 Class Loaders
( ) Grove #90, 91, 94W Mity-Mite Regulators
( ) Grove Flexflo
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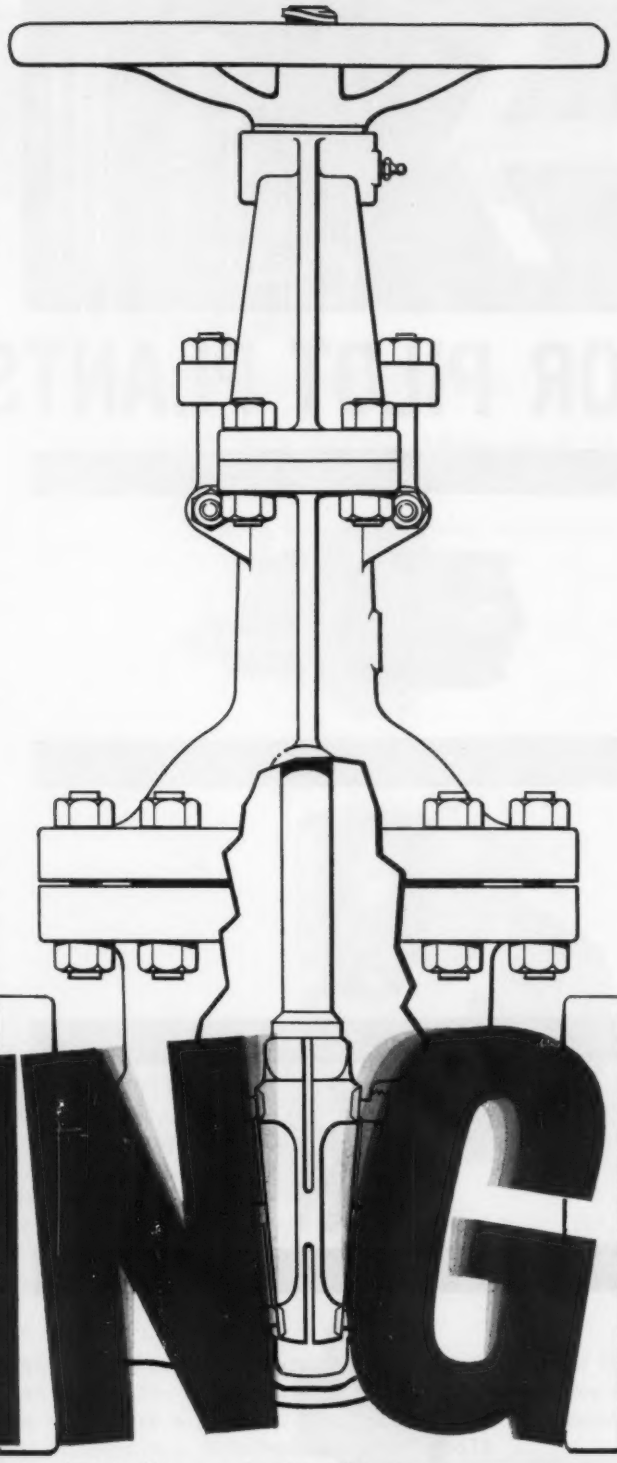
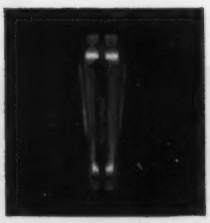


LIVING

Walworth's last word in positive sealing! When valve bodies are tortured out of shape by line pressure, temperature or deflection—new Walworth living wedge Gate Valves still seal tight! It's because of Walworth's unique one-piece split disc gate that lives in the body...flexes and gives, to stay mated to the seat in spite of body distortion. Yet new Walworth living wedge Gate Valve operates at low torque, can't bind, jam or stick—and is economical, needing



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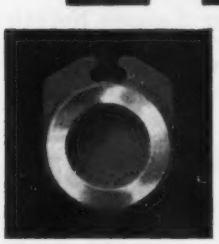

minimum replacements. Get new Walworth living wedge Gate Valves in 150 and 300 pound ASA ratings, 2″ to 24″. See your Walworth distributor for details, or write to Walworth Company, 750 Third Avenue, New York 17, N. Y.

WALWORTH

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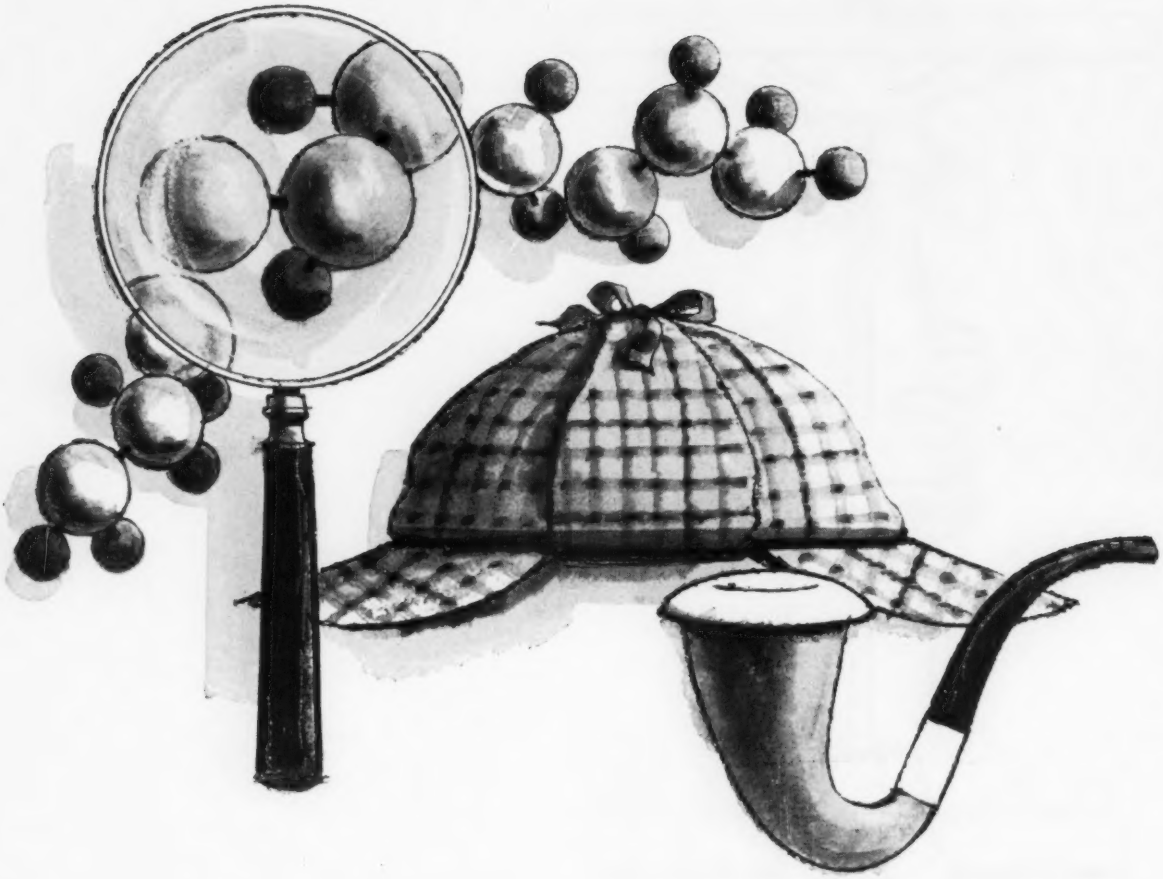

THE CASE OF THE MISSING CARBON ATOMS

Sticky problem. Clearly not a case of theft. No evidence of foul play, either.

Whole thing started with "n-paraffins"—family of methane molecules. N-paraffins appear in crude oil and source rock—sediments in which oil was formed. Shifty, though; also crop up in rock which never harbored any oil. Very misleading to oil-hunters. How to tell one kind of rock from the other?

One piece of evidence to go on: N-paraffin molecules very careless about their make-up. Some have an *even* number of carbon atoms; others, an odd number. H-m-m-m. Any telltale ratio between the number of "even" and "odd" molecules?

One way to find out. Count the carbon atoms.

Ever count atoms? Easier said than done. Invisible, you know. Takes all kinds of latest, most advanced scientific techniques—fractionation, spectroscopy, radiocarbon dating, quick-freezing of cores. That sort of thing. Calls for first-rate scientists. Socony Mobil assigned job to task force of scientists under physicist Ellis Bray. Resourceful man, Bray. Persistent, too. Had to be—counted carbon atoms in *quadrillions* of n-paraffin molecules.

Job took lots of patience, correlation. This and a bit of shrewd deduction led science fellows right to the key. Simply this: If your count shows almost exactly as many molecules with *even* number of carbon atoms as with *odd* number, your molecules come from source rock. Good hunting ground for oil. But if "odd" molecules outnumber "even" by as little as 20 in 100, sediments not oil-bearing.

Elementary, of course. But good thing to apply to oil exploration. Can sometimes mean difference between success and failure. Big difference. Tantalizing, though, this discovery. Gives new clues to even deeper mystery—how oil formed in first place. Really *big, that one. Way it goes in this research thing.*

Lots of chaps working alongside Ellis Bray in Mobil's $25,000,000-a-year research program. Some 1,500 of them. Both sexes. Turn imagination into ideas, ideas into better products and processes. Clever.

Good thing, this probing frontiers of science. Not only for Mobil, but for everyone who does business with Mobil—customers, employees, licensees, investors.

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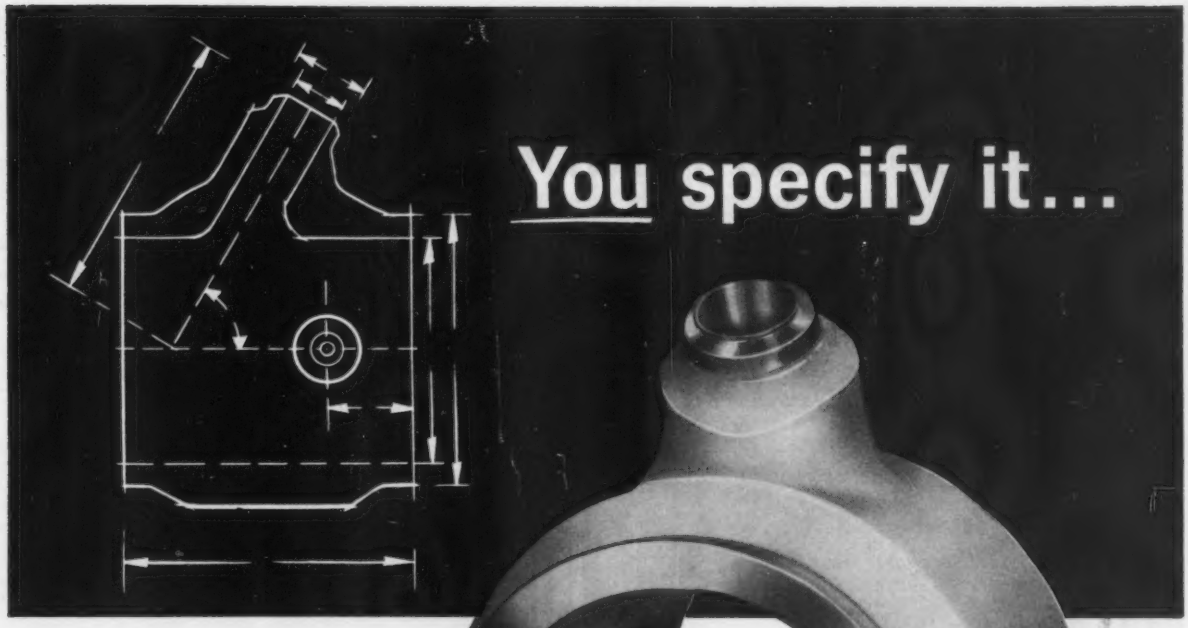

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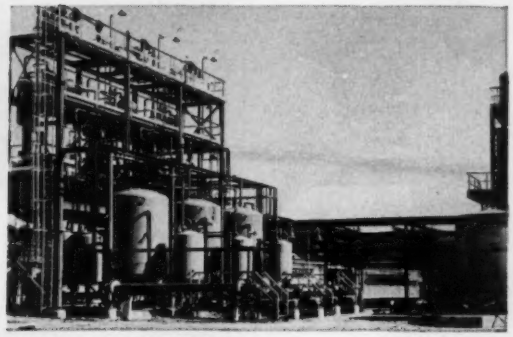

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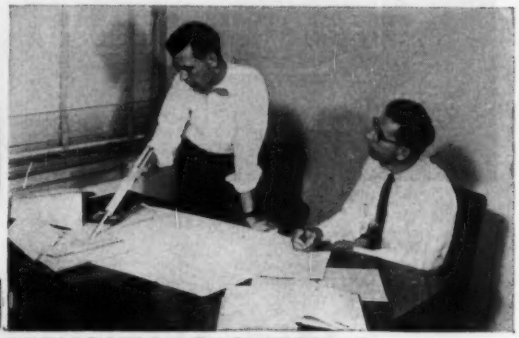

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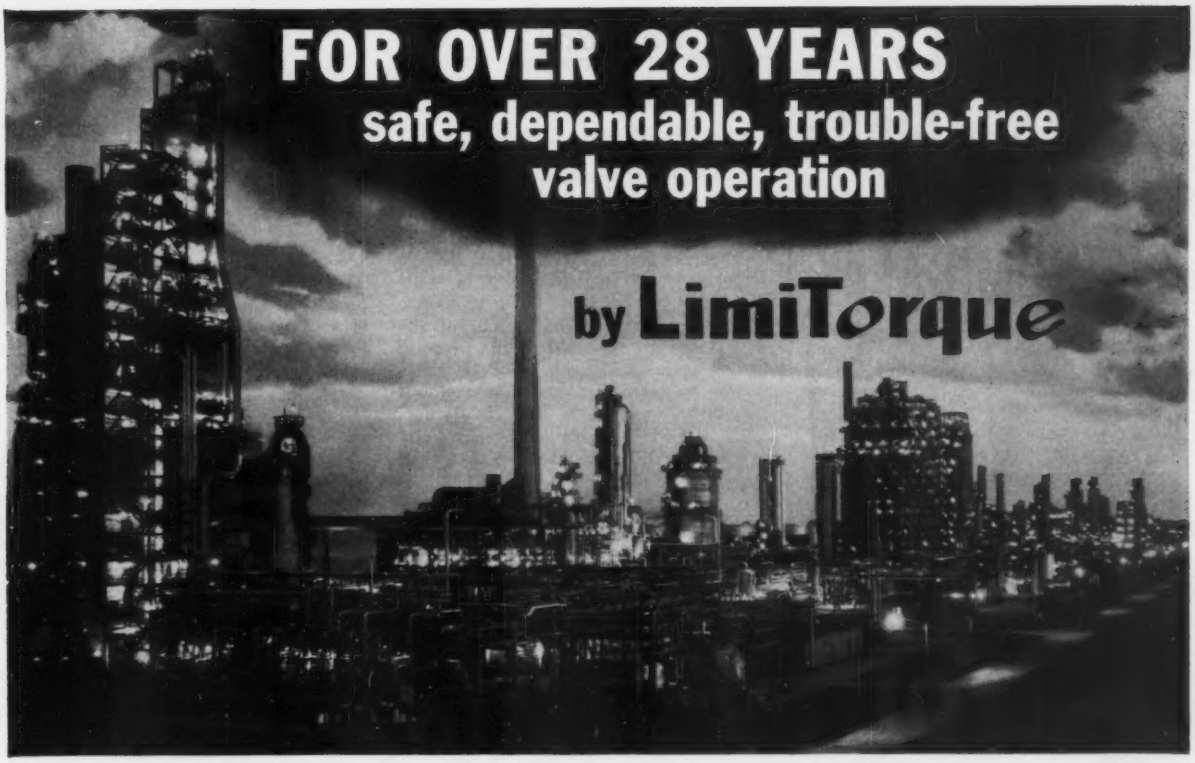

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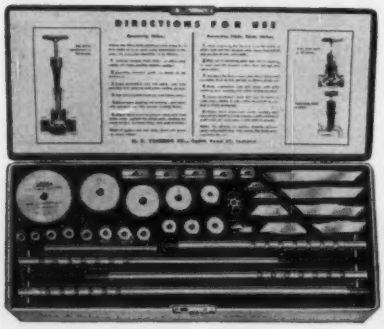

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Clarification Asked

I was very pleased to see in your May issue "Rating Baffled Exchangers" by Mr. Abe Devore. Could he clarify the concept of C_2 and α, and discuss the relationship of A_x to A_e—the values of A_e may be five (5) times the value of A_x—for the problem No. 2 (without by-pass strips) $A_e = 196$ in^2, while $D_1 \times l_s = 194$ in^2—is this possible?

In extending the comparison of the methods to problem No. 2, the pressure drop on the shell side is 9-14 times greater by Kern and Donohue methods than by the Tinker method discussed.

Errata Listed. Please advise me of any errata in addition to the following list:

P.223 $C_{14}^{1/2} = 1.035$ (rather than 1, within 2% for 16"-37" units — smaller diameters result in longer deviations)

Comparison of the Methods of Calculations

Tinker's Method

P.231 $R_{ep} = (.942)\ (411) = 387$
(.942 rather than)
$\therefore f_x$ 0.104 (.972 from Table I)

Donohue's Method

P.231 $A_x = l_s \left[D_1 - d_2 \left(\frac{D_s - d_2}{p} + 1 \right) \right]$
(relocate d_2 term)

Kern's Method

P.232 $h_o = \frac{12\ j_h\ P'\ \phi}{d_e}$
(12 rather than 16.1)
$\therefore h_o = 40.8$ BTU/hour ft^2 °F.

P.232 $f_x = .00175/1.2$
$\therefore f_x = .00146$
$\therefore \Delta P = .97/1.2 = .808$ psi
(at the end of the discussion of shellside pressure drop Ref. 10)

Hugh Spencer
B. F. Goodrich Chemical Co.
Cleveland, Ohio.

AUTHOR'S REPLY

(1) Clarification of the C_2 and α terms

I refer you to Table D-16, p. 130 of the 4th edition of "Standards of Tubular Exchanger Manufacturers Association," (TEMA). This is a table relating circular segments and chords to the ratio H/D_1. (This table, incidentally, is also available in a number of standard references, e.g.—Perry's Chem. Eng. Handbook). The ratio of the area of a segment to that of a complete circle is given by the term listed under "A" in the above reference, divided by $\pi/4$. For example, a 20 percent baffle cut results in:

$$C_2 = 0.1118/0.785 = 0.142$$

In formulating an expression for the number of tubes in any given size shell, Tinker writes the equations:

$$N_2 = \frac{.785\ C_1\ D_s^2}{P^2} \quad \text{for square-pitch}$$

and $$N_2 = \frac{.785\ C_1\ D_s^2}{.866\ P^2} \quad \text{for triangular-pitch}$$

where C_1 = fraction of theoretical maximum tube count

Tinker chose a value of $C_1 = .94$

The cross-sectional area of tubes in the window zone is then given by

$$A \text{ tubes} = \left(\frac{.785\ C_2\ D_1^2}{CP^2} \right) (.785\ d_2^2)$$

where $C = 1.0/0.94 =$ 1.063 for square pitch

and $C = 0.866/0.94 =$ 0.922 for triangular pitch

The free-flow area in the window-zone is

$$AW = .785\ C_2\ D_1^2 \left[1 - \frac{.785}{C} \left(\frac{d_2}{P} \right)^2 \right]$$
$$= .785\ C_2\ D_1^2\ \alpha$$

The term α represents the bracketed expression. I calculated the following values of α:

	$P/d_2 =$ 1.25	1.30	1.40	1.50
→ ▷	$\alpha =$ .456	.497	.566	.622
→ □ and → ◇	$\alpha =$ .529	.563	.622	.672

(2) Values of A_e vs. A_x

What is really involved here is a distinction between gross movement of the fluid in the shell to a *directed* cross-flow movement, i.e., speed vs. vector velocity in a direction normal to the bundle. The basic idea behind Tinker's analysis consisted in just this resolution of *velocities* rather than a meaningless undirected speed. The answer to your question is an emphatic affirmative, and this situation will occur in any exchanger with a low value of bundle-penetration.

(3) Comparison of Pressure-drop for Problem No. 2

You are correct. I calculated 21.7 psi using Donohue's method, a value 13.7 times the *clean* pressure drop computed by my recommended equation. For an explanation of this discrepancy, I refer you to Donohue's original paper. (Ind. Eng. Chem., Vol. 41, No. 11, p. 2509, 1949). Donohue states: "Wide variations in values of friction factor have been noted—and the variation has been ascribed to only part of the flow penetrating the tube bundle. The effects which fractional flow penetration will exert on friction factor and heat transfer coefficient may be readily computed when it is recalled that friction factor is a function of G^2 and heat transfer coefficient is a function of $G^{0.6}$. For example, if only half the total flow penetrates the tube bank, the friction factor will be reduced to one quarter of the value for full penetration—." In my second illustrative problem, the value of F_h happens to be 0.1763 *without* by-pass strips and 0.1986 *with* by-pass strips. This would result in:

ΔP clean $= (.1763)^{1.8}$
ΔP fouled $= .044\ \Delta P$ fouled

and ΔP clean $= (.1986)^{1.8}$
ΔP fouled $= .054\ \Delta P$ fouled

or approximately a *twenty*-to-one ratio:

To suppose *full* cross flow bundle penetration for this type of problem (for a pressure-drop calculation) is to lean way overboard on the conservative side. For D_1/l_s ratios of 2 to 5, the correction to a clean condition can be made in the manner indicated by my first illustrative problem if a *rough* comparison is desired.

(4) $C_{14}^{1/2}$ Value

The approximation $C_{14}^{1/2} = 1.0$ was used *only* in equation (30), i.e.;—in the evaluation of M. Equation (7) was evaluated using actually computed values of

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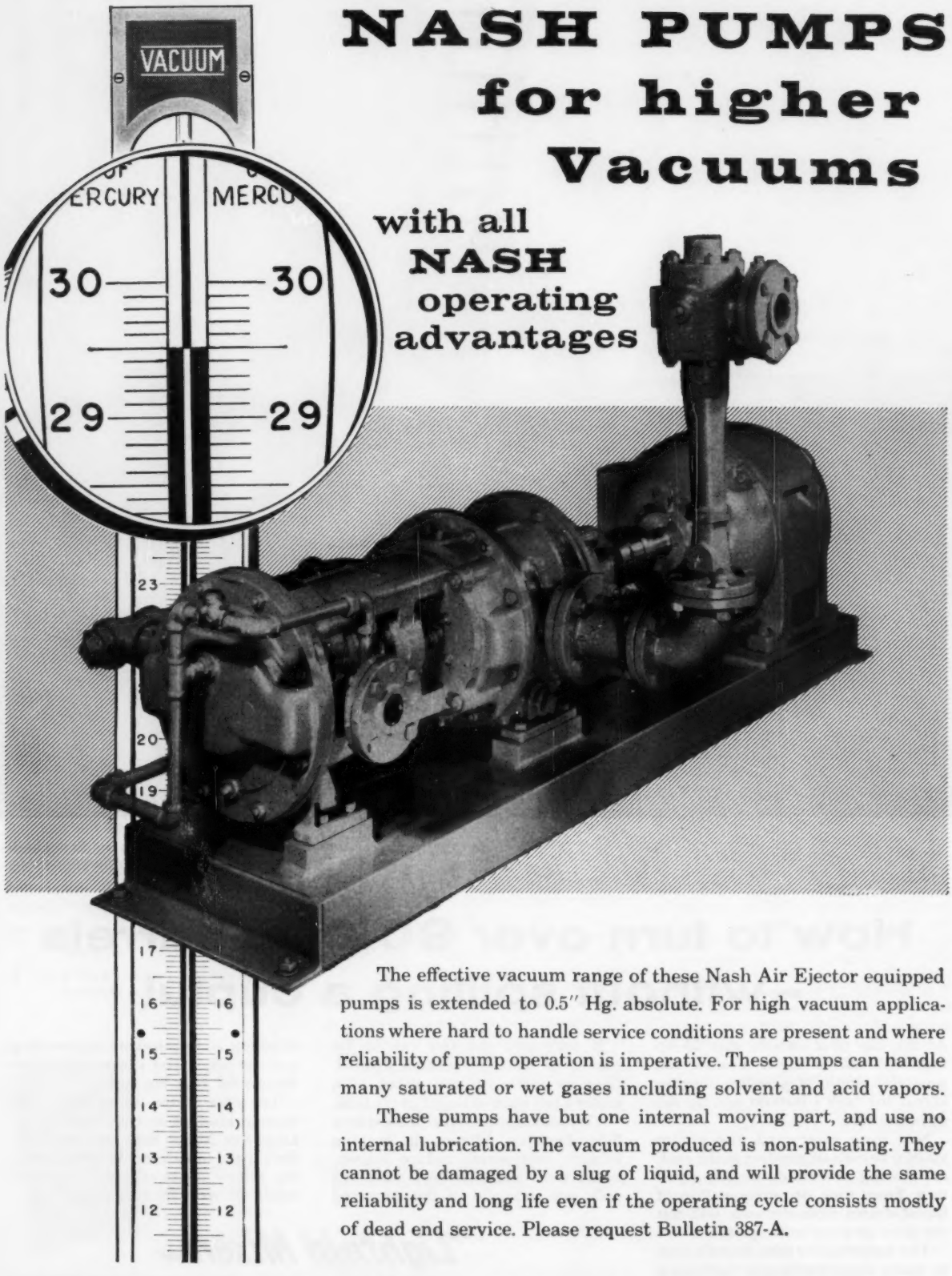

with all NASH operating advantages

The effective vacuum range of these Nash Air Ejector equipped pumps is extended to 0.5" Hg. absolute. For high vacuum applications where hard to handle service conditions are present and where reliability of pump operation is imperative. These pumps can handle many saturated or wet gases including solvent and acid vapors.

These pumps have but one internal moving part, and use no internal lubrication. The vacuum produced is non-pulsating. They cannot be damaged by a slug of liquid, and will provide the same reliability and long life even if the operating cycle consists mostly of dead end service. Please request Bulletin 387-A.

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C_{14}½. The net effective error on the computed values of h_o is less than 2 percent.

(5) Tinker's Method

You looked up the value of .942 under the wrong heading. Problem 1 treats an exchanger with square-pitch, not triangular pitch.

(6) Donohue's Equation for A_x

You are correct. Fortunately, this does not affect the illustrative problem as $d_s = 1.00$ in.

(7) Kern's Method

You overlooked the viscosity conversion factor. Kern's j-factor is

$$j_H = \frac{h_o D_{es}}{k} \left(\frac{c\mu}{k}\right)^{-1/3} \left(\frac{\mu}{\mu_w}\right)^{-0.14}$$

Converting μ to Z with a 2.42 value and D_{es} to d_{es} with a value of 12, this becomes

$$h_o = (12)\ (2.42)^{1/3} \frac{j_H \left[k\left(\frac{CZ}{k}\right)^{1/3}\right] \phi}{d_{es}}$$

$$= \frac{16.1\ j_H\ P'\ \phi}{d_{es}}$$

On the other hand, I overlooked the 1.2 factor in converting fintube friction factor to bare-tube. Your friction calculation is correct.

Abe Devore
Industrial Process Engineers, Houston

Suggests Credit

The nomograph for the density of air ("Estimate Forced-Draft Fan Costs" by N. H. Prater and D. W. Antonacci, PETROLEUM REFINER, Vol. 40, No. 7, July 1961, page 129) is identical to one of mine published in the September 1960 issue of "Power."

I think that proper credit should be given.

F. Caplan
Oakland 10, Calif.

AUTHOR'S REPLY

After reviewing b .n nomographs, I do agree that the layout and scales for both nomographs are indeed the same and only nomenclature and units differ. However, this is not surprising since the basic equation was used to construct both nomographs, namely:

$$\rho = \frac{0.825\ P\ (1+H)}{T \times (0.622+H)}$$

The nomograph published in my article was prepared for me by a member of our Applied Mathematics Group using the equation shown above. Since I am not a subscriber to "Power," I had no knowledge of the existence of your nomograph until the HP-PR editor forwarded a copy to me. Had I known of its existence, I most certainly would have contacted you for permission to use your nomograph, with proper credit reference, thereby eliminating the duplication of effort.

N. H. Prater

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THICK SHEETS
in one pass

Use of **NEW** continuous-rolling technique here—shows uniform seal, with all Keys preserved, and no signs of shear

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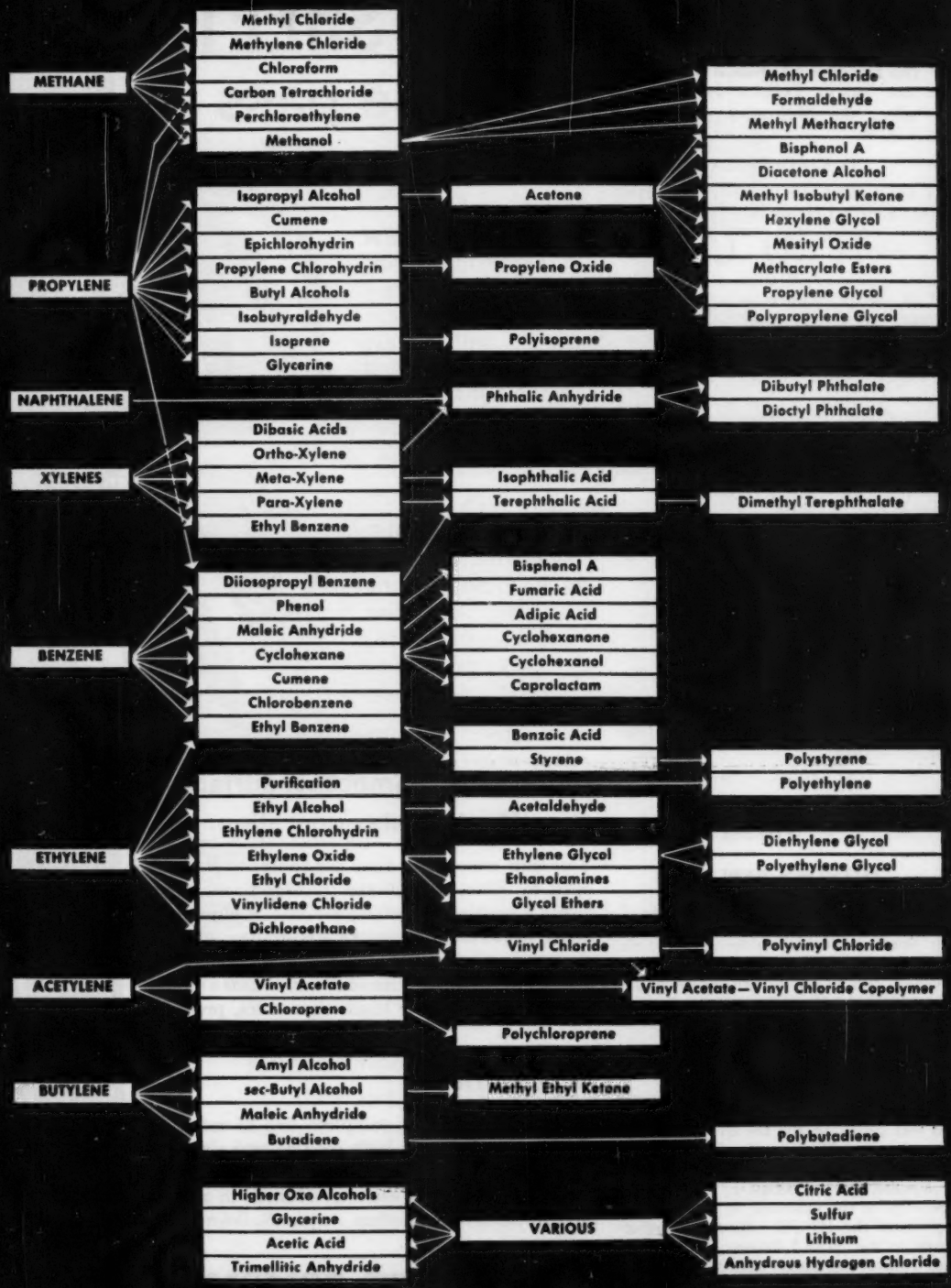

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A SPECIAL REPORT by Frank L. Evans
Mechanical Engineering Editor

valves

A look at the valves used in the industry today with emphasis on how to select the right valve for performance and economy

Engineers are taking a longer look at valves in the hydrocarbon processing industry today because they represent a sizable amount spent for process equipment both in capital expenditures and maintenance. In dollars spent, valves account for approximately 8 percent of new plant capital expenditures. Replacement purchases account for about 10 percent of the maintenance budget. In this industry, most of the valves are of the gate type (approximately 75 percent) with plug valves accounting for about 10 percent, ball valves 2-3 percent, check valves 1 percent, needle valves 1-2 percent, and the rest didived between globe, butterfly, diaphragm, slide, etc.

In selecting a valve, many engineers think that if they have a 600 psi process line that a 600-pound valve is required. According to API 600 and ASA B16.5 it depends entirely on the temperature of the process fluid. If the maximum temperature is low enough, a 300-pound valve could easily meet the code requirements and save the engineer several hundred dollars in valve costs. This report tells the engineer exactly how to make the right selection for performance and economy.

PLUG VALVES—API 600 (Lubricated and Nonlubricated)

(Figures indicate base price in dollars)

SIZE (Inches)	150 lb. PATTERN								300 lb. PATTERN								400 and 600 lb. PATTERN										900 lb. PATTERN						
	Short		Regular		Venturi		Round Port Full Bore		Short		Regular		Venturi		Round Port Full Bore		Short		Regular		Venturi			Round Port Full Bore			Short		Regular		Venturi		Roun Full
	RF	WE	RF	WE	RF	WE	RF	WE	RF	WE	RF	WE	RF	WE	RF	WE	RF	WE	RF	WE	400 lb RF	600 lb RF	WE	RF	WE	RF	WE	RF	WE	RF	WE	RF
1																																
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1½																																
2	113																															
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3																																
4	235																															
6	525												635								985	1,070										
8	715												860								1,260	1,410										
10	895												1,180								1,730	2,030										
12	1,120												1,666								2,310	2,540										
14																																
16																																
18																																
20																																
24																																

FIGURE 1—Gate valves and plug valves specified in API 600 with base cost figures added.[1]

Valve specification and selection

There are two main steps the designer must take in selecting a valve:

- He must first decide on a valve type between two broad categories for the process application.
- Then, he must select the specific valve from one of these two classes that has the proper characteristics for the application.

The first step in selecting a valve is rather easy because the designer merely decides whether it should be a stop valve or a throttling valve. Also, relatively few throttling valves are used on process lines. They are used in the hydrocarbon processing industry primarily for utility service, air and water.

Selecting the specific valve in one of these two classes for the application is more difficult. The choices under stop valves (i.e. full open or closed) are gate, ball, plug (both lubricated and nonlubricated), slide, piston, check, blind, etc. The choices under throttling valves (i.e. control flow between full open and closed) are globe, angle, needle, butterfly, diaphragm, etc.

Example. Assume that in the particular application a stop valve is required. The first question the designer must ask himself is "Must the valve shutoff be bubble-tight?" If the fluid being handled is light such as a gas, a gate valve would not be satisfactory for bubble-tight service. The reason for this is that to prevent leakage there must be a minimum permissible surface variation. To obtain this, the two closing surfaces of the valve must be within four light waves of being optically flat to prevent leakage of very light petroleum liquids or gases. The surfaces of the wedges and seats in a gate valve cannot be maintained in such a condition, because the sealing of a gate valve depends upon the deformation of the mating surfaces caused by wedging the tapered gate between the seats. Temperature changes and external piping stresses will not allow a gate valve to maintain a bubble-tight closure.

The designer must then consider another stop valve and his next choice would be the plug type. In considering the lubricated plug valve, he must compare the fluid being handled with the lubricant used to seal the plug valve for compatibility. His next choice would be a nonlubricated plug valve which uses a resilient material to lubricate the plug and assure bubble-tight closure. One big problem he faces with this selection is that if the valve is in a process area handling inflammable fluids, the possibility of a fire may rule out the use of plastic seating materials.

After considering bubble-tightness (which is not required in a very large number of refinery and petrochemical services) the designer's selection is based on process conditions such as temperature, pressure, corrosive conditions, suspended solids in the fluid, method of operation, ease with which the valve operating position may be observed by the operator, cost, and maintenance.

CODES HELP SELECT AND SPECIFY

Code Standards have been developed to simplify the designer's job of selecting the correct valve to meet his process conditions.

API Standard 600[1] covers two general types of valves:

- Gate valves (rising-stem, outside-screw-and-yoke).
- Lubricated and nonlubricated plug valves.

1,500 lb.							2,500 lb.							
PATTERN							PATTERN							
Regular		Venturi		Round Port Full Bore			Short		Regular		Venturi		Round Port Full Bore	
RF	WE	RF	WE	RF	WE		RF	WE	RF	WE	RF	WE	RF	WE

Valve price basis

Base prices are given only for those valves used most frequently in the Hydrocarbon Processing Industry. For example, in gate valves probably 95 to 98 percent of all applications are in the 150-lb. through 600-lb. series and in sizes 2, 4, 6, 8, 10 and 12-inch. In plug valves, the same pressure ratings apply and the principal pattern is the Venturi except possibly the short pattern is used more in the 150-lb. class. Colored squares without price figures are used to illustrate other valve sizes, classes and patterns covered by the standard.

All valve base prices are subject to discounts. It's difficult to generalize on the discounts available but the valves shown could be purchased for perhaps 30 to 40 percent less than the base price. However, the difference between the base price of a 2-inch, 300-lb. gate valve and a 2-inch, 600-lb. gate valve should be about the same as the discounted price. So, you could use this difference to evaluate the extra cost of using a higher rated valve. Larger discounts are usually available on plug valves than on gate valves so a direct comparison of the base prices would not be too reliable. The base price shown represents raised face, flanged-end, cast steel valves, with standard trim conforming to API 600. Ring joints would cost approximately $15 to $20 additional on gate valves. Welding ends may not cost any more than flanged ends on gate valves. On plug valves, welding ends may cost less than flanged ends by $50 to $100. Ring joints must be specified as a special end and an additional charge will be made. One special note to plant engineers: cast steel valves purchased out-of-stock carry a 25 to 30 percent penalty over factory shipments.

GATE VALVES—API 600

(Figures indicate base price in dollars)

SIZE (Inches)	150 lb.			300 lb.			400 lb.			600 lb.			900 lb.			1,500 lb.			2,500 lb.		
	RF	RJ	WE	RF	RJ	WE	RF	RJ	WE	RF	RJ	WE	RF	RJ	WE	RF	RJ	WE	RF	RJ	WE
1																					
1¼																					
1½																					
2	120			171						239											
2½																					
3																					
4	207			304			445			523											
6	335			555			900			1,058											
8	490			738			1,392			1,638											
10	734			1,133			2,028			2,385											
12	975			1,547			2,639			3,105											
14																					
16																					
18																					
20																					
24																					

The specification covers flanged and butt-welding-end forged and cast-steel gate and plug valves for refinery service.

API 600 ratings cover only the following nominal pipe sizes and pressures: 1, 1¼, 1½, 2, 2½, 3, and 4 thru 24 inch in even sizes at 150, 300, 400, 600, 900, 1500, and 2,500-pound ratings. Figure 1 illustrates the valves covered by the specification and shows comparative costs.

Some refiners prefer to use valves no smaller than one-inch. However, occasionally three quarter inch valves and even one half inch valves are used in hydrocarbon sampling service.

Pressure-Temperature Ratings. The ASA standard for steel pipe flanges and flanged fittings, ASA B16.5-1957,[2] applies "also to cast and forged steel flanged end and butt-welding-end valves of corresponding primary service pressure rating and size." The ratings shown in Tables 1 and 2 are the maximum allowable non-shock pressures (psig) at the tabulated temperatures and may be interpolated between the pressures shown. These same tables are repeated in API 600 and form an excellent starting place for selecting a specific gate or plug valve. Compare your selection with Figure 1 to be sure it is the most economical valve for the application.

These two tables represent about 97 percent of all valves used in a typical hydrocarbon processing plant. Both standards also include pressure-temperature ratings in the 900 lb., 1,500 lb., and 2,500-pound class and the designer is referred to these standards for applications within these classes.

A common mistake made by many plant operators and designers who do not use these or manufacturer's

tables is to *assume* that if the process line is operating at a certain pressure, a valve of that same pressure class must be used. For example, if you have a fluid operating under 600 psi pressure at 500° F, you don't need a 600-pound valve. Note from Table 2 that a 300-pound carbon steel valve will operate within the code providing a 625 psi rating at 500° F. The 300-pound valve can be purchased at a saving of $150 to $200 over the purchase of the same sized 600-pound valve.

Low Temperature Ratings. The ratings at —20 to 100° F given for material covered in Tables 1 and 2 shall also apply at lower temperatures. The ratings for low temperature service of the cast and forged materials listed in ASTM A352 and A350 shall be taken the same as the —20 to 100° F rating for carbon steel in the tables.

Some of the materials listed in the rating tables undergo a decrease in impact resistance at temperatures lower than —20° F to such an extent as to be unable to safely resist shock loadings, sudden changes of stress or high stress concentrations. Therefore, products that are to operate at temperatures below —20° F shall conform to the rules of the applicable Codes under which they are used.

Valve Loading. The designer should be particularly careful in using low pressure rating valves with relatively heavy walled pipe.[3] The imposed moment caused by construction or caused by expansion may be beyond the structural capacity of the valve. For large-diameter piping, venturi ports are sometimes used on valves (particularly when motor operated). Also, standard valves one or two sizes smaller are used with reducers with conventional lines. The body of a venturi valve is usually designed with consideration for the moment which may be applied by the larger piping.

A valve should be able to carry the loading from the connected piping similar to a standard tee of comparable pressure-temperature rating. It should also be free of warpage or distortion to permit operation and tight shutoff.

Refinery Piping Code, ASA B31.3-1959.[4] This code states in section 300.1.1 that it covers all piping located within a refinery. In section 300.1.5, piping is defined as including valves.

Pressure. Section 301.2.2 states that the piping component shall be designed for an internal pressure representing the most severe condition of coincident pressure and temperature expected in normal operation (including fluid head).

Temperature. The design temperature of the metal representing the most severe condition of pressure and temperature is stated in paragraph 301.3.2 for threaded and welding-end valves to be 95 percent of the fluid temperature. For flanged valves the design temperature should be 90 percent of the fluid temperature.

Materials of Construction. Valve materials and stress values are specified in Tables 302.3.1a and .1b and 326.1 of the code. The materials fall under ASTM specifications and API material specifications, however special valves may be used constructed of material not listed in these tables provided they meet the design standards required in Division 304 of the code.

Flanges. Section 308.1.1 states that "consideration should be given to avoiding the use of slip-on flanges where many large temperature cycles are expected and particularly if the flange is not insulated."

In section 308.3, 150-pound steel flanges may be bolted to cast iron valves having either class 125 cast integral or screwed flanges. If such construction is used, it is

TABLE 1—150 lb. Pressure-Temperature Rating Table from API Standard 600[1]

Note: These ratings are in pounds per square inch gage and are all subject to stipulations in pars. 45-50, API 600 which form a part of this table.

Service Temperature (Degrees Fahrenheit)	MATERIAL															
	Carbon Steel	Carbon Molybdenum	Cr-Mo ½—½	Cr-Mo 1—½	Cr-Mo 1¼—½	Cr-Mo 2—½	Cr-Mo 2¼—1	Cr-Mo 3—1	Cr-Mo 5—½	Cr-Mo 5—½ Si	Cr-Mo 9—1	Types 304	Types 347 and 321	Types 316	Types 310
—20 to 100 [c]	275														
150	255														
200	240														
250	225														
300	210														
350	195														
400	180														
450	165														
500	**150**														
550	140														
600	130														
650	120														
700	110														
750	100														
800	92														
850	82 [a]														
875	75 [a]		75 [a]												
900	70 [a]		70 [a]												
925	60 [a] [b]		60 [a] [b]												
950	55 [a] [b]		55 [a] [b]												
975	50 [a] [b]		50 [a] [b]												
1,000	40 [a] [b]		40 [a] [b]												
Hydrostatic shell test pressure								425							
Hydrostatic seat test pressure								300							

[a] Products used within the jurisdiction of Sect. I, "Power Boilers," of the *ASME Boiler and Pressure Vessel Code* are subject to the same maximum temperature limitations placed upon the material in Table P-7, 1956 edition thereof.

[b] Products used within the jurisdiction of Sect. 1, "Power Piping," of *ASA B31.1: Code for Pressure Piping* are subject to the same maximum temperature limitations placed upon piping of the same general compositions in Table 2a, of ASA B31.1—1955.

[c] For ratings at temperatures below—20 F see Par. 45, API 600.

TABLE 2—300 lb. Pressure-Temperature Rating Table from API Standard 600[1]

Service Temperature (Degrees Fahrenheit)	MATERIAL											Types			
	Carbon Steel	Carbon Molybdenum	Cr-Mo ½—½	Cr-Mo 1—½	Cr-Mo 1¼—½	Cr-Mo 2—½	Cr-Mo 2¼—1	Cr-Mo 3—1	Cr-Mo 5—½	Cr-Mo 5—½ Si	Cr-Mo 9—1	304	347 and 321	316	310
—20 to 100 [a]						720						615		720	
150						710						585		710	
200						700						550		700	
250						690						520		690	
300						680						495		680	
350						675						470		675	
400						665						450		665	
450						650						430		650	
500						625						410		625	
550						590						395		590	
600						555						380		555	
650						515						370		515	
700	470	480	480	485	485	480	485	480	485	480	485	355	495		490
750	425	445	445	450	450	445	450	445	450	445	450	340	470		465
800	365	410	410	415	415	410	415	410	415	410	415	330	450		440
850	**300** [a]	370	370	385	385	370	385	370	385	370	385	320	425		415
875	260 [a]	355 [a]	355	365	365	355	365	355	365	355	365	315	415		400
900	225 [a]	335 [a]	335	350	350	335	350	335	350	335	350	310	400		390
925	190 [a] [b]	320 [a] [b]	320	335	335	320	335	320	335	320	335	305	390		375
950	155 [a] [b]	**300** [a] [b]	**300**	315	315	**300**	315	**300**	315	**300**	315	305	380		365
975	120 [a] [b]	280 [a] [b]	280	**300**	**300**	280	**300**	275	**300**	250	**300**	300	370		350
1,000	85 [a] [b]	215 [a] [b]	215	255	265	215	265	240	250	190	290	**300**	355		340
1,025				215	230 [a]	180	235	215	215	155	240	295	345		325
1,050				170	190 [a]	145	200	190	180	120	190	290	335		315
1,075				135	165 [a]	120	170 [a]	165	145	105	150	275	325		**300**
1,100				95	135 [a]	95	145 [a]	135	115	85	115	255	310		290
1,125				75 [a] [b]	110 [a] [b]	75	125 [a]	115	95	75	95	225	**300**		270
1,150				55 [a] [b]	85 [a] [b]	60	105 [a]	95	75	60	75	195	260	290	250
1,175				45 [a] [b]	65 [a] [b]	50	85 [a] [b]	70 [b]	65	50	65	175	215	260	225
1,200				35 [a] [b]	40 [a] [b]	40	70 [a] [b]	50 [b]	50	40	50	155	170	235	205
1,225												135	140	205	185
1,250												110	115	180	165
1,275												100	95	160	140
1,300												85	75	135	120
1,325												75	65	115	100
1,350												60	50	95	80
1,375												55	45	80	70
1,400												50	40	70	55
1,425												40	35	60	45
1,450												35	30	50	40
1,475												30	30	45	30
1,500												25	25	35	25
Hydrostatic shell test pressure							1,100					925		1,100	
Hydrostatic seat test pressure							750					625		750	

preferred that the 1/16-inch raised face on steel flanges be removed. If the raised face is removed and a flat ring gasket extended to the inner edge of the bolt holes is used, the bolting shall be carbon steel not stronger than ASTM A307 Grade B; if a full faced gasket is used, the bolting may be heat treated carbon steel (ASTM A261) or alloy steel (ASTM A193). If the raised face of the steel flange is not removed, the bolting shall be carbon steel not stronger than ASTM A307, Grade B.

Three-hundred-pound steel flanges can be bolted to cast iron valves having either class 250 cast iron integral or screwed flanges, without any change in the raised face of either flange. If such construction is used, the bolting shall be carbon steel not stronger than ASTM A307, Grade B.

Drains and Bypasses. Section 311.3.4 states that drains and bypasses may be attached to a valve by socket welding provided the socket depth, bore diameter and shoulder thickness conforms to the requirements of ASA B16.5

Physical dimensions of all valves used in process work should conform to the following standards:

ASA B16.1—gives face-to-face dimensions of iron flanged and welding-end valves and includes cast iron and steel gate, globe, angle, and swing check valves in various sizes and pressures.[5]

ASA B16.5—includes ring-joint dimensions and facing for steel flanges and flanged fittings.[2]

API Standard No. 600—covers flanged and welding ends, steel wedge gate and plug valves, valves for refinery use. API Standard 6D covers steel gate, plug and check valves for pipeline service.

MSS Standard Practice SP-42 and SP-44—are also concerned with dimensional standards for valves.[6]

Two other valve standards are published by the United States Printing Office, "United States Commercial Standards and Simplified Practices Recommendations,"[7] and "Federal Specifications."[8]

Practically all process screw-end valves are threaded by the American Standard Pipe Thread. However, special threads are: API line pipe thread or other special purpose threads.

Size Designation. Valves are usually described by a numbering system. The size markings on the valve consists of a number indicating the nominal pipe size in inches followed by another set of numbers indicating

the flange rating. For example, 8-900 designates an 8-inch size valve with 900-pound standard steel flanges.

The designer should also refer to manufacturers' catalogs to find detailed descriptions and specifications of specific valves.

Valve Markings. Most manufacturers comply with MSS standard marking system SP-25.

The service symbols are as follows:

S = Steam	G = Gas
O = Oil	L = Liquid
W = Water	

Generally, when numbers alone are used in marking a valve the valve is rated for steam service at the pressure indicated by the numbers.

Temperature markings. When valves are rated for services other than steam, they will carry the temperature rating marked with numerals followed by the letter "F". The exception to this rule is cast iron valves which usually carry no temperature markings. The user should consult the ASME Boiler Code, the Pressure Piping Code, etc. for limiting conditions of cast iron valves.

Valve Specifications. Ordinarily valves are included in the piping specification and a typical valve and catalog number with the words "or equal" following this specification. This is followed by a valve number which is used on the piping drawing to reduce the number of notes on the drawing. It is also used in the bill of material lists and purchase orders. Manufacturers are often requested to include this valve number on a tag attached to the valve for positive identification during storage.

The following items should be included in any valve specification:

- Quantity of valves.
- Sizes of valves (nominal).
- Manufacturer's Catalog No., if known.
- Valve materials (special trim and body materials only if required).
- Service pressure or operating head and max. pressure.
- Max. temperature or min. if below zero.
- Open-closed service or throttling.
- Type of trim.
- Fluid being handled (corrosivity).
- Type of stems, i.e. inside screw, OS&Y, etc.).
- Position valve is to operate, if other than vertical.
- Valve opening. State whether valves are to "turn right to open (clockwise) or turn left to open (counter clockwise).
- End type (screw, flange, welding, etc.). (If flange end, specify raised face or ring joint type.)
- Special flange drilling. If flanges are to be drilled other than to ASA standards, give bolt circle diameter, number of bolt holes, size of bolt holes and state whether bolt holes straddle the center lines of the valve or whether they are on the center line.
- Operator (handwheel, wrench operated, motor operator, etc.).
- Nameplate markings (special) and shipping instructions.

A valve list is often made which includes the numerical order of the valves used and shows the face-to-face dimension and other data such as ASA flange ratings.

Piping specifications ordinarily include a list of all the process and utility fluids in the plant.[9] This list will include a description of each type of fluid, its pressure, temperature and service peculiarities. By studying this list, the particular service for which the valve is being selected can be easily obtained.

Gate valves

Gate valves account for about ¾ of all valves in refineries, petrochemical and gas processing plants. Why does this one type of valve far outclass the others in percentage of valves in operation? The answer is that it happens to be the right type of valve for most continuous process plant operations. A majority of the valve requirements are for stop valves—full open or closed with infrequent operation. The gate valve fits the bill. It has been established over a long period of time as a dependable item of equipment, and with many manufacturers supplying one form or another, gate valves are hard to beat on price. Also, because the seating surfaces are in metal-to-metal contact, the hazard of a leaking valve in case of fire is a minimum.

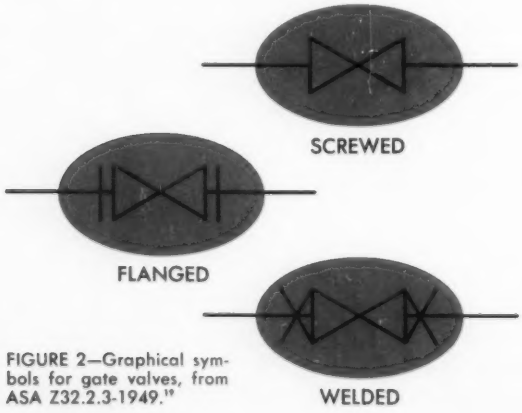


FIGURE 2—Graphical symbols for gate valves, from ASA Z32.2.3-1949.[11]

Block Valves are those valves used to shutoff a separate system. The term is loosely used and may be understood to mean any valve which is used for shutoff service rather than for throttling.[9]

A Bleed Valve is a small valve used to draw off liquids.

A Double Block and Bleed means two block valves with a bleed valve located between them. Bleed-off valving for pressure instrumentation on hot lines is provided with a double block and bleed valve. These valves and the bleed piping for hot services should not be less than ½ inch or ¾ inch in size and are arranged so that a rod may be driven up the valve and fitting.

Many refiners still believe in the tried-and-true method of using double block and bleed valves for bubble-tight service.

Block valves and drains have been installed in HF alkylation units in the water piping on the overhead

condensers from the azeotropic, alkylate, depropanizer and dependentanizer towers at low point to eliminate water pockets which might freeze.[10]

Available today are standard steel gate valves with replaceable fluorinated plastic seat rings. These valves also have auxiliary metal seat rings for protection in case of fire. With this arrangement, a bubble-tight closure can be obtained and body vent connections permit the valve to be used in place of double block and bleeder valve arrangements. This type of valve is limited by the seating material temperature limitations which are up to 600° F. Another disadvantage is that they cost about 50 percent more than standard gate valves.

Plastic-coated gate valves have not been developed satisfactorily as yet because the sharp corners in the design damages the plastic coating.[11] The most successful type of lining for gate valves has been hard rubber and high nickel alloy gates and seats.

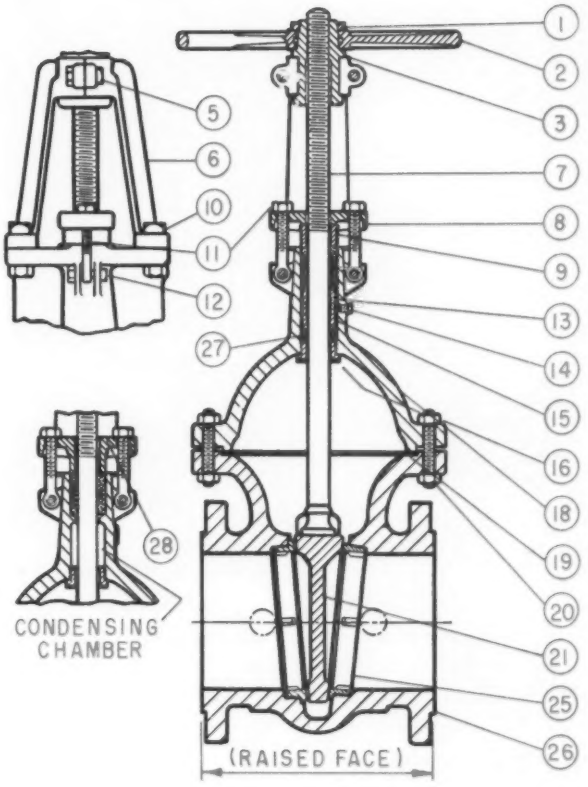
Throttling. Ordinarily it is not recommended to use gate valves in throttling service. However, with some fluids which contain material that would clog or impede the flow through a restricted orifice, gate valves have been used successfully for throttling these fluids. In these cases, the gate valve can operate satisfactorily only if the stem of the valve is in a horizontal position. In other words, the valve must be placed in a vertical flow line. If the stem is down, the bonnet will fill with sediment and with the stem up, the groove at the bottom tends to fill with sediment, preventing full closure.[12]

Prior to the trend in the use of motor operators and control room indicators, there was and still is a definite preference in refineries for the use of gate valves for partial throttling because it was easy for the operator to see the valve position from the control house on a rising-stem gate. Also, refiners do not want to take a high pressure drop by replacing gates with globe valves. Cooling water is still throttled in a great many plants with gate valves. However, the valve is very poor for throttling service because in a partially open position the gates become eroded fairly rapidly.

Coking Service. A through conduit type gate valve has proven very satisfactory in coking services where other valves have given trouble. This type of valve is one in which there is no body cavity exposed to line fluids in the open or closed position. A 4-inch, 300-pound valve of this type has been installed on the soaking coil outlet of a furnace since 1954 with no reported difficulty. Another refiner has used a 3-inch, 300-pound valve on an evaporator fuel oil line since 1955 with success. A 4-inch, 300-pound valve has been used on a synthetic tower bottoms line since 1954 with no leaks or coking troubles. For propane service, this valve may be used with fluorinated plastic seat ring inserts. The disadvantage of using this type valve is that it costs about 10 percent more than a standard steel gate valve, is slow in operation, and must be used in full open or full closed position.

Standard gate valves with tapered seats are generally recommended for use where coke or tar-like compounds might build up on the valve parts under high temperature and solidify on cooling.

O S &Y. Most process gate valves are specified with an outside screw and yoke. This is done because of the



PART NAMES

1. Handwheel nut.
2. Handwheel
3. Yoke nut.
5. Yoke bolting.
6. Yoke
7. Stem.
8. Gland flange.
9. Gland.
10. Yoke bolting.
11. Gland bolts or gland eyebolts and nuts.
12. Gland lug bolts and nuts.
13. Stem packing.
14. Drain plug.
15. Lantern.
16. Bonnet back-seat bushing.
18. Bonnet.
19. Bonnet gasket.
20. Bonnet bolts and nuts.
21. Wedge
25. Seat ring.
26. Body.
27. Stem wiper packing.
28. One-piece gland (alternate).

FIGURE 3—Wedge gate valve; OS & Y, rising-stem, cast or forged steel. This API Standard 600 sketch shows some stipulations in specification and variations of available commercial designs. Sketch reflects designs now available, but implies no sponsorship in whole or in part by API for a particular design.[1]

corrosive and high temperature service encountered in process streams. For noncorrosive service, the thread can be inside the valve body screwing into the body as is the case with non-rising-stem gate valves and small globe, angle, Y and needle valves.[13]

Rising and Non-Rising Stem. The rising stem gate valve is frequently used on both water and process piping. It requires more space for installation but is an advantage in handling corrosive streams that tend to damage stem threads in other valve types.

On water piping, the non-rising-stem gate valve is used extensively. The chief disadvantage is the fact that the degree of opening cannot be easily seen.[14]

The non-rising-stem gate valve with a vent in the

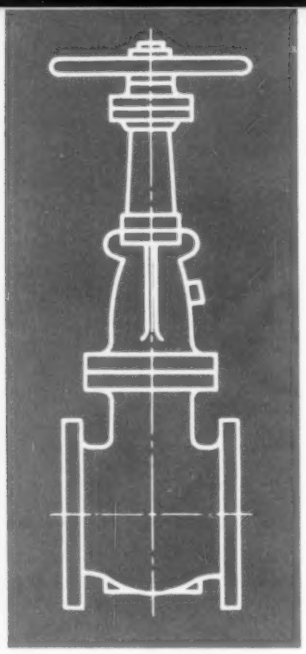


FIGURE 4—Typical gate valve with symmetrical shape, from ASA B16.5-1957. Sketch is illustrative only and does not infer design.[2]

body operating similar to the double block and bleeder valve arrangement is especially useful for guarding against the comingling of products in light oil pipeline and tank farm service.

For High-Pressure Installation, gate valves should be of heavy construction and are often motor operated. A good design calls for a small bypass line to equalize the pressure on both sides of the gate before opening.[14]

On high-pressure service or on large cast steel gate valves, (3 inches or larger) the use of a bypass permits equalization of pressure on both sides of the valve and makes operation easier. Bypasses are also used to warm steam lines before the main valve is opened.

Bronze Gate Valves. These valves are used where the size is usually not to exceed three inches and pressure is under 400 to 500 psi.[15] Various types of seats are used depending upon the fluid handled. The fire hazard excludes most bronze valves from process area applications.

Iron-Body, Bronze-Mounted Valves. These valves are made as small as 1½-inch sizes but are principally used in sizes about three inches. They are available in gate, globe and check valve types.

Small Steel Gate Valves. This is a 600-pound steel gate valve in ½-inch and ¾-inch sizes. These valves have hard faced seats or 13 chrome seats with a hardness of 250 to 500 Brinell. Most of them have a 13 chrome wedge and a bolted bonnet although welded and union bonnets are available. Spiral wound or soft iron gaskets are used.

Gate Valve Specifications. These typical specifications are recommended for gate valves in the following services:

100-pound air, 50-pound caustic, 15-pound condensate, 50-pound fuel, 150-pound hydrocarbon, and 40-pound exhaust. The ratings are 230 psi at 100° F, and 150 psi at 500° F, and 100 psi at 750° F (max.).[9]

For 1½-inch and smaller, use 600-pound SWP forged carbon steel screwed, inside screw stem, union bonnet, 11-13 percent chrome stainless steel trim. For air and condensate service use 150-pound SWP brass, screwed, rising stem, inside screw.

For 2-inch and larger gate valves, use 150-pound ASA standard cast carbon steel, flanged, OS&Y, 13-13 percent chrome stainless steel trim, 1/16-inch raised face. For condensate service use 125-pound ASA standard cast iron, flanged OS&Y brass trim, and stem.

In steam services at 275 psig and 410° F, and hydrocarbon service at 250 psig and 750°-800° F (Max.) with the following rating:

500 psi at 100° F.
375 psi at 500° F.
300 psi at 750° F.

Use the following gate valve specifications:

For 1½-inch and smaller, use 600-pound SWP forged carbon steel screwed, inside screw stem, union bonnet, 11-13 percent chrome stainless steel trim.

For 2-inch and larger gate valves, use 300-pound ASA standard cast carbon steel, flanged, OS&Y, 11-13 percent chrome stainless steel trim, 1/16-inch raised face.

These specifications shall apply to gate valves used in the following services:

100-pound fire water, 75-pound service water, 75-pound cooling water, 45-pound sanitary water.

For 1½-inch and smaller, use 150-pound SWP brass screwed, rising stem, inside screw.

For 2-inch and larger, use 125-pound ASA standard cast iron flange OS&Y brass trim, and stem.

For 2-inch and larger gate valves, use 125-pound ASA standard cast iron flange OS&Y (for fire service use double-disc, non-rising stem, brass trim, only).

Plug valves

Lubricated Plug Valves. The problems with the originally developed lubricated plug valves were the lubricants low resistance to heat, solvents and chemicals. Other problems were product contamination by the valve lubricants and the expense and trouble required to lubricate and maintain this type of valve. Present day lubricants and coating of the plug surfaces have considerably reduced these problems.

Lubricants have been developed for plug valves which contain a dispersion of gas in the lubricant which can be compressed to about half of its expanded volume. When the lubricant is forced into the valve under pressure it is compressed. Later, it expands and feeds automatically into the valve lubricant grooves only as needed.[13] This has been done to reduce lubrication frequency.

Manufacturers report that in 99 out of every 100 service calls for plug valves, the only thing that was wrong was that the valve needed lubrication.

Basic advantages cited for lubricated plug valves are:

- They are quick acting (one quarter turn to open or close).
- They are simple in operation (a minimum of moving parts, linkages or mechanical parts to break down).
- They require a minimum amount of space to be installed.

The tapered plug produces an automatic close fit. The lubrication feature increases pressure tightness, minimizes the exposed seating surfaces to the fluid being handled and makes the value easier to operate.

Because of the large seating surfaces on plug valves, even small ones may be hard to operate unless serviced frequently. Above 6-inch in size, it is generally recommended to use gear-operators on the valve (See Table 3). This, however, tends to cancel the speed advantage of quarter-turn operation. Because lubricant channels do not line up except in the full-open or full-closed position, these valves cannot be used for throttling except in emergency.

The lubricated plug valve is generally most satisfactory in 6-inch sizes and smaller and for applications involving temperatures less than 500° F.

Throttling. For gas throttling service, the plug valve can be successfully used. In a partially closed position, the inlet lip of the plug and the inlet side of the body are the surfaces that receive the impact of the gas passing the plug face. When the gas enters the plug cavity, its velocity is reduced. The final exit passed the downstream plug lip imparts the final velocity change and the result is that the dirt and foreign material receives its highest velocity after the throttling surface and not at a point prior to this surface. The plug valve is a good gas throttling valve in that it displays the ability to control low flows. The initial opening of the rectangular port plug is very small and increases in small increments until the plug has actually turned several degrees. Special plugs can be specified to provide even a greater ability to control the flow in extremely low flow ranges.[16]

Three-Way Valves. For certain applications, a three-way type valve is required. The lubricated plug valve has proven to be the most satisfactory valve for this application.

HF Alkylation Service.[10] Valves of 6-inch size and smaller at service temperatures of 150° F and less are usually lubricated plug valves. The principal advantage lies in the fact that no stem packing is required. All valves 8-inch and larger or valves operating at a temperature above 150° F are conventional gate, globe or angle-type globe valves. These valves are fitted with plain carbon steel or carbon-moly steel trim, 18-8 stainless steel stems and a lubricated-type stuffing box with a lantern ring for injection of lubricant. Aluminum foil packing with a neoprene core is used to pack these valves. If a tight shut-off is necessary for maintenance and repair, double block valves are used. A bleeder valve is installed between the block valve to break down the pressure and to detect leakage.

Troubles. In HF alkylation operation, there are a few cases of corrosion in valves but this is not serious.[10] The major problem is with sticking of the plugs and

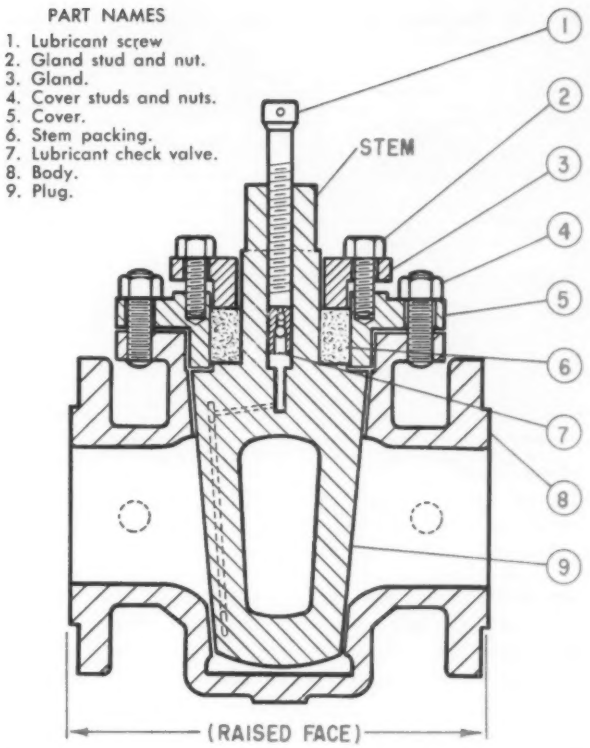


FIGURE 5—Plug valve; cast or forged steel. This sketch is from API Standard 600.[1]

replacement of broken parts. The broken parts include equalizer rings, thrust buttons, diaphragms and plugs. Six-inch plugs have given particular trouble some of which are cracked badly or even shattered. This is probably caused by excess hardness of the plugs. Overstressing of cover plate stud bolts has also given trouble.

Packed Cock. A small steel sleeve-packed cock valve is used in small sizes one quarter-inch through 1-inch for sampling valves. These valves usually have a 1200-pound rating and are used on 350-pound propane sampling lines and also in light oil propane storage.

Cocks are universally used on small lines such as compressed air. Sometimes the taper of the plug is small and it tends to wedge in the body of the valve making it difficult to turn. Special designs are available where a lubricant is forced by a screw through the stem of the cock and grooves in the plug which lift the plug by hydraulic pressure. This works very well for ordinary service but in many cases the lubricant dissolves. If the taper is too great, the line pressure tends to lift the plug out of its seat. Another difficulty is that the opening in the plug is approximately rectangular therefore the area of the opening changes very rapidly with a slight amount of rotation when the cock is barely opened but has practically no change when the cock is almost fully opened.[12]

In Sour Crude Service, it has been suggested that the hardness of the plug should be specified lower than the standard 40-45 Rockwell C to 35-40 Rockwell C. The lowering of the plug hardness prevents hydrogen

TABLE 3—Plug Valve Stem Operation from API Standard 600[7]

Rating	Pattern	SIZE (Inches)	
		Direct Operation	Gear Operation
150 lb	Short and venturi	1 to 8, inclusive	8 to 24, inclusive
	Regular	1 to 6, inclusive	6 to 24, inclusive
	Round port	1 to 4, inclusive	4 to 24, inclusive
300 lb	Short and venturi	1 to 8, inclusive	8 to 24, inclusive
	Regular	1 to 6, inclusive	6 to 24, inclusive
	Round port	1 to 4, inclusive	4 to 24, inclusive
400 lb	Venturi	4 to 6, inclusive	6 to 24, inclusive
	Regular	4	4 to 24, inclusive
	Round port	4	4 to 24, inclusive
600 lb	Venturi and regular	1 to 4, inclusive	4 to 12, inclusive*
	Round port	1 to 3, inclusive	3 to 12, inclusive*
900 lb	Venturi and regular	3	3 to 12, inclusive*
	Round port	..	3 to 12, inclusive*
1,500 lb	Venturi and regular	1 to 3, inclusive	3 to 12, inclusive*
	Round port	1 to 2, inclusive	2 to 12, inclusive*
2,500 lb	Venturi and regular	1 to 3, inclusive	3 to 8, inclusive

* Requirements for sizes above 12 in. will be developed if and when a demand is indicated.

sulfide corrosion. Also, it is recommended that a hard-faced seat be used to prevent hydrogen embrittlement. A carbon steel seat is standard but has been reported to have failed because of hydrogen embrittlement in crude service.

Several lubricated plug valves are now coated with a fluorinated plastic (for service to 450° F) or molybdenum disulfide to make the valves easier to open and close. This improves the lubrocisity but at the same time would not let the valve leak if a fire melted the thin plastic coating because the valve lubricant would continue to seal the plug against leaks.

Lubricated plug valve manufacturers have a slogan that this is the only valve in which you can reface the seats while in service. Their point is to add more lubricant which is, in fact, the seat.

One other consideration for lubricated plug valves is that in several sizes this type of valve is cheaper than a gate valve.

Hydrocarbon Service. For light hydrocarbons, gas services and for many corrosive services the plug valve is often specified because it is available in many materials suitable for high temperature service. They are not as commonly used as gate valves in process work however and some of their critics cite these disadvantages:[9]

- There is no visible way to tell that the valve is open as is true with the rising-stem gate valve.
- Past experience has shown a great possibility for the plug freezing open or closed.
- For the lubricated type plug valve, a constant lubrication program must be maintained.
- A more rigid support must be provided for this type of valve in the smaller sizes.

Injecting a semi-solid lubricant into the valve has the effect of lifting the valve plug somewhat which makes the valve easy to open or close.

Plug Valve Specifications. These specifications are recommended for plug valves in the following typical services:[9] 100-pound air, 50-pound caustic, 15-pound condensate, 50-pound fuel, 150-pound hydrocarbon, and 40-pound exhaust. The ratings should be specified as 230 psi at 100° F, 150 psi at 500° F, and 100 psi at 750° F (Max.).

For 1¼-inch size, specify, 2,000-pound WOG, forged carbon steel, screwed, wrench operated, lubricated plug valve.

For 2-inch to 6-inch size plug valves, specify 150-pound ASA standard cast carbon steel, flanged, 1/16-inch raised face, wrench operated, lubricated plug valve.

In steam services at 275 psig. and 410° F, and hydrocarbon service at 250 psig and 750-800° F (Max.) rated 500 psi at 100° F, 375 psi at 500° F, and 300 psi at 750° F, specify plug valves as follows:

For 1¼-inch size, specify 2,000-pound WOG, forged carbon steel, screwed, lubricated plug valve.

For 1½-inch plug valves, specify 300-pound WP cast carbon steel, screwed, wrench operated, lubricated type.

For 2-inch to 4-inch size plug valves, specify 300-pound ASA standard cast carbon steel, flanged, 1/16-inch raised-face wrench operated lubricated plug valves.

Nonlubricated Plug Valves. This type of valve was originally developed for oil and gas production valves where a positive seal with relatively free maintenance was needed. The nonlubricated plug valve has eliminated many troubles for refiners in the following services where lubricated valves were previously used: coker vapor lines (temperature and coking) cat polypropane dryers (temperature and light gases), cat reformers (light gases, hydrogen service), lube clay filters (steam, air, wash naphtha and oil), propane storage and loading (product contamination).

The nonlubricated plug valve may be successfully used in refinery loading services in 2, 3, 4-inch sizes rated at 300 psi. The advantages of using this type of valve are to obtain a bubble-tight closure, easy repair by replacing the slips, and the compact size with relative quick opening action. The chief disadvantages are high costs (40 percent greater than steel gate valves) and low temperature limits of 180° F.

This type of valve has given very good service in transfer and loading operations in 3- and 4-inch sizes. Also, they have been used very satisfactorily in 4-inch and 6-inch sizes for vacuum truck service. Another example is their use in catalytic polymerization unit piping operating at 1,000 psig and 400° F.

The nonlubricated plug valve may generally be used in services in which gate valves are satisfactory ranging from near vacuum to 10,000 psig, from minus 50° F to 1600° F and from corrosive chemicals to light hydrocarbons. Many of these valves are designed for in-line maintenance and can be completely disassembled and all wearing parts removed without removing the body from the line. For high temperature service above 500° F, the bonnet of these valves is modified to decrease the heat transfer to the operating mechanism and to provide for additional stem cooling. The stuffing box is also deeper and designed for the use of compression packing. A lantern ring and cooling fluid connection can also be provided. Most of these valves are available with rectangular ports. However, round ports may be specified.

For high-temperature operation, the valves are supplied with 13 percent chrome plugs and seats as standard

trim. Fluorinated plastic packing is used for service below 500° F.

Pipeline Products. For bubble-tight positive segregation of products in pipelines, the nonlubricated plug type valves have proven very satisfactory. This type of valve may be specified with plastic seat rings bonded to 14-36 percent nickel-iron alloy slips and a flag-type indicator on top to give definite open-closed identification.

Plastic-coated Plug Valves have recently been gaining wide acceptance in the process industry. They are performing very well in highly corrosive fluid services and under relatively high temperature conditions. Because the coatings are relatively thick (20-30 mils), pinholes in the coating have not been a problem. The only real damage reported has been to plastic-coated valves in abrasive fluid service or used for throttling.[11]

The real drawback to plastic-coated valves is their temperature limit which is now only about 200° F.

Some manufacturers use plastic coatings on the seats and others coat the plugs. Failures have been reported in both cases with the seat coated valve failing first when these valves were used on the suction and discharge side of a reforming unit. After replacing the plugs and/or seats, the valves worked satisfactorily except they would stick if the valves were not operated once every eight hours.

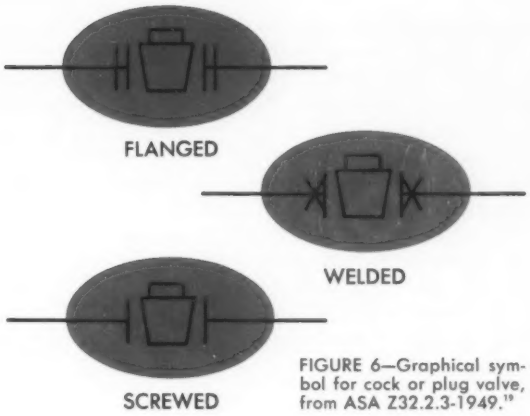


FIGURE 6—Graphical symbol for cock or plug valve, from ASA Z32.2.3-1949.[19]

Ball valves

The ball valve is not new having been around for about 73 years. The new interest in this type of valve comes from the development of materials to improve the sealing of these valves such as synthetic rubber, nylon and fluorinated plastics.[11] The original ball valves were not recommended for bubble tight service because of the metal-to-metal seat. The new seating materials now provide a tight seal as well as easy operaton. Less maintenance and noncontamination of the fluid stream with lubricants are cited as additional advantages. The valve is cheaper and easier to make than other type valves and it is easier to obtain a tight seal with a sphere than with other shapes.

Manufacturers have estimated that the ball valve is suitable for one out of five present valve applications.

Another advantage cited for ball valves is their good application for remote operation because they open and close so easily with only one quarter turn. With the trend to increased automatic control, this advantage is indeed great for the ball valve.

The primary use for ball valves in the hydrocarbon processing industry is for valve applications under 400° F and pressures less than 4,000 psi. Although with graphite seats, they could be operated at temperatures as high as 1000° F.

The ball valve is often spring loaded on the upstream side to compensate for any play that may develop to insure tight closure at lower differential pressures and to prevent material from getting between the seating surfaces.

The disadvantages cited for ball valves are:

- Pressures are limited to the compressive strength of the seating material.
- Temperatures are limited to the limits of the seating material.
- The valve shuts off in one direction only and may permit liquid to pass back upstream in some ball valves at approximately 15 pounds pressure.
- On compressor bleed off applications, these valves have been known to vibrate considerably and gradually open.

Advantages for ball valves are that they are quick opening the same as plug valves, one quarter turn, and tests have shown very little wear for an extremely high number of operations. They provide a very tight closure on hard to hold fluids. They are comparatively free from operator abuse such as closing down too hard on gates, neglect of lubrication, tightening down on plugs, etc. They are non-sticking and the pressure drop through the valve is negligible because of the smooth, full-pipe-size opening. It will pass large particles easily through the valve opening and there is a minimum of erosion by suspended solids in the stream. There is no contamination of the stream by lubricants. Maintenance costs are low and they are easy to repair. They are also cheaper than other valves including plug valves of which they are less expensive by approximately 4 percent.

Application. The most prominent applications for ball valves in refineries at present are for loading valves on both tank car and truck racks, utility air service connections, utility water service connections, gas bleed-off valves, sample connection valves, low pressure steam service connections, fire systems, etc.

One refiner reports that when using a 1½-inch ball valve with a screwed connecting pin and O-ring, on an LPG loading hose, the pin broke when the valve froze causing the valve to leak.

Other recent applications of ball valves include the replacement of plug valves in chemical loading racks in 1½-inch sizes and also in safety showers. They also re-

place gate and plug valves in caustic service.

One refiner reports that xylene went right through gate valves but that a 4-inch ball valve in tank car loading, with 150-pounds flanged ends and fluorinated plastic seats has worked very satisfactorily.

It is very possible that a trend is developing to replace plug and gate valves with ball valves for some process services especially if ball valves prices continue to drop.

One big drawback that engineers are concerned about when considering ball valves for process areas is that their soft seats present a possible safety hazard in case of fire. Another problem reported is that it is difficult to find a full port valve in sizes over two inches. That is, most of the valves greater than 2-inch in size are reduced port type.

The fire hazard may not be as serious as many designers think because recent tests show that fluorinated plastic seats although damaged did not leak after a ball valve was exposed to a direct hydrocarbon flame for 15 minutes. Also, in some designs, when the seat melts the ball slides to the downstream side providing a metal-to-metal seal.

Petrochemical plant engineers seem to be accepting ball valve applications at a much greater rate than oil refiners or gas processing plant operators. Again the fire hazard in process areas seems to be the deciding factor.

Globe valves

The globe valve is generally used in small size piping for throttling or control. They are used primarily in steam and air service where throttling and a positive shut-off is required. The installation of this type of valve is made so that the flow is up through the seat ring and against the bottom of the disc or globe. This prevents accumulation of debris above the disc which in turn causes operating difficulties.[14]

For throttling service, the globe valve is superior

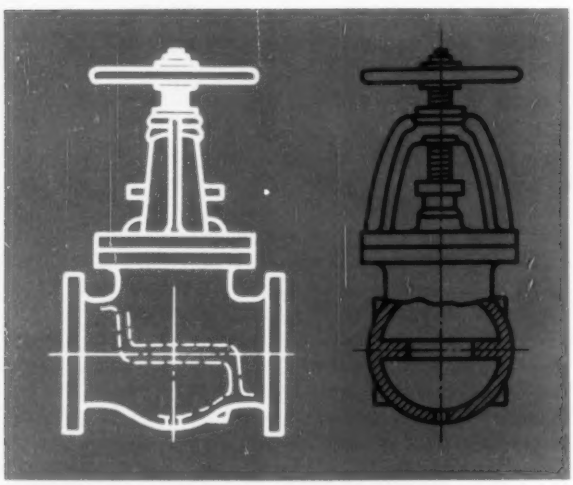


FIGURE 7—Typical globe valve with symmetrical shape, from ASA B16.5-1957.[2]

because of relatively small wear on the valve seats. They are also used in throttling if a tight shut-off is required. A large size globe valve is generally more expensive than a gate valve and many users purchase globe valves only in small sizes (1½-inch and below). The conventional globe valve offers a considerable resistance to fluid flows. Therefore, the angle valve and the "Y" valve was developed to reduce that resistance. Angle valves are not used very extensively because the 90° bend in process piping would subject the valve to considerable stress.[9]

Globe Valve Specifications. These specifications are recommended for globe valves in the following typical services:[9]

100-pound air, 50-pound caustic, 15-pound condensate, 50-pound fuel, 150-pound hydrocarbon, and 40-pound exhaust. The ratings are 230 psi at 100° F, 150 psi at 500° F and 100 psi at 750° F (Max.).

For 1½-inch and smaller globe valves, specify 600-pound SWP forged carbon steel screwed, inside screw stem, union bonnet, 11-13 percent chrome stainless steel trim. For air and condensate service, use 250-pound SWP brass, screwed, rising stem, union bonnet valves.

For 2-inch and larger globe valves, specify 150-pound ASA standard cast carbon steel, flanged, OS&Y, 1/16-inch raised face, 11-13 percent chrome stainless steel trim. For condensate service use gate valves for 2-inch and larger. Also, use gate valves for all sizes above 6-inch.

In steam service at 275 psig and 410° F, and hydrocarbon service at 250 psig and 750-800° F (Max.) rated 500 psi at 100° F, 375 psi at 500° F, and 300 psi at 750° F, specify as follows:

For 1½-inch and smaller globe valves, specify 600-lb. SWP forged carbon steel screwed, inside screw stem, union bonnet, 11-13 percent chrome stainless steel trim.

For 2-inch and larger globe valves, specify 300-lb. ASA standard cast carbon steel, flanged, OS&Y, 1/16-inch raised face, 11-13 percent chrome stainless steel trim.

In 100-pound fire water, 75-pound service water, 75-pound cooling water, and 45-pound sanitary water service, specify as follows:

For 1½-inch and smaller globe valves, specify 250-pound SWP brass, screwed, rising stem, union bonnet.

Above 2-inch for this service, it is recommended that gate valves be used.

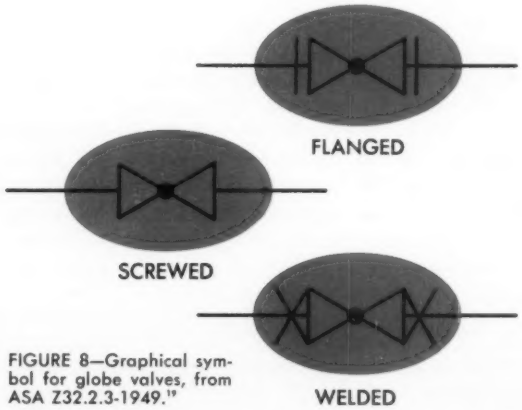


FIGURE 8—Graphical symbol for globe valves, from ASA Z32.2.3-1949.[19]

Check valves

The lift-check and swing-check are the two major type of valves used in process work. The lift-check or ball check is most often used in sizes two inch and smaller. It has a ball or guided plug which is lifted by fluid pressure and does not have a tendency to slam as does the swing-check type. Therefore, it is preferable for services having irregular or frequent reversals of flow. For sizes larger than two inches, the swing-check valve is most often used and chattering caused by frequent flow reversals can be stopped by using this type of valve equipped with an outsider lever and weight.[9] In process pump piping, checks are used after the discharge nozzles to prevent liquid backup in case of pump failure.

Specifications. These example specifications are recommended for check valves in the following typical services:[9] 100-pound air, 50-pound caustic, 15-pound condensate, 50-pound fuel, 150-pound hydrocarbon, and

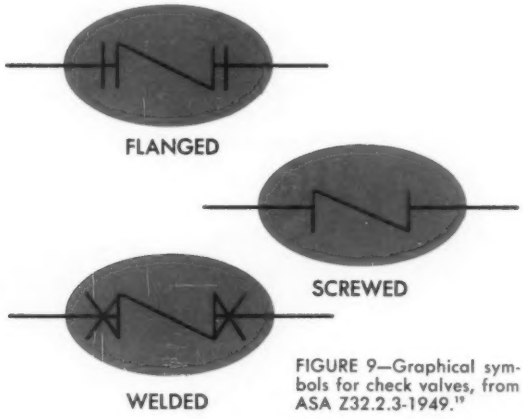


FIGURE 9—Graphical symbols for check valves, from ASA Z32.2.3-1949.[19]

40-pound exhaust. The ratings specified should be 230 psi at 100° F, 150 psi at 500° F, and 100 psi at 750° F.

For 1½-inch and smaller, specify 600-pound SWP forged carbon steel screwed, horizontal, piston type, 11-13 percent chrome stainless steel trim. For air and condensate service, use 250-pound SWP brass screwed, horizontal piston type, nickel alloy seat and disc.

For 2-inch and larger check valves, specify 150-pound

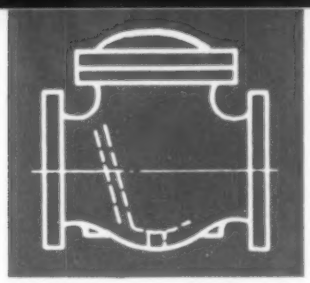


FIGURE 10 — Typical check valve with symmetrical shape, from ASA B16.5-1957.[2]

ASA standard cast carbon steel, flanged, 1/16-inch raised face, swing-type 11-13 percent chrome stainless steel trim. For condensate service, use 125-pound ASA standard cast iron, flanged, swing-type, brass trim.

In steam service at 275 psig and 410° F, and hydrocarbon service at 250 psig and 750-800° F (Max.) rated 500 psi at 100° F, 375 psi at 500° F, 300 psi at 750° F, specify as follows:

For 1½-inch and smaller, specify 600-pound SWP forged carbon steel screwed, horizontal, piston, type 11-13 percent chrome stainless steel trim.

For 2-inch and larger check valves, specify 300-pound ASA standard cast carbon steel, flanged, 1/16-inch raised face, swing-type, 11-13 percent chrome stainless steel trim.

In 100-pound fire water, 75-pound service water, 75-pound cooling water and 45-pound sanitary water service, specify as follows:

For 1½-inch and smaller check valves, specify 250-pound SWP brass screwed, horizontal, piston type, nickel alloy seat and disc.

For 2-inch and larger check valves, specify 125-pound ASA standard cast iron, flanged, swing-type brass trim.

Check List for Check Valve Specifications:

- Manufacturer's catalog or figure number, if known.
- Nominal size.
- Fluid conditions (pressure, temperature, corrosivity).
- Flow (Steady or pulsating).
- Are cushioning chambers or dashpots required? (i.e. for extremely pulsating flows).
- Bypass required, if any, and location if different from catalog.
- Outside lever and weight—if valve to be sensitive to flow reversal or to open under minimum pressure.
- End type (flanged, screwed, welding, etc.) (If flanged, specify raised face or ring type joint).
- Type of lifting gear, if required.

Miscellaneous valves

Butterfly Valves. This type of valve is used in large piping water service, eight inches and larger. Several cooling tower lines use 20 and 30-inch butterfly valves. In cat cracker air service, a 95 percent shutoff is reported using butterfly valves. On the water side of coolers, butterfly valves are used in 8, 10 and 12-inch sizes.

For cooling tower water lines, butterfly valves with a resilient rubber lining which serves as both the seat and the flange gasket have proved to be very economical. These valves will fit between a standard 125-pound or 150-pound flange. They are limited to 180° F and 150

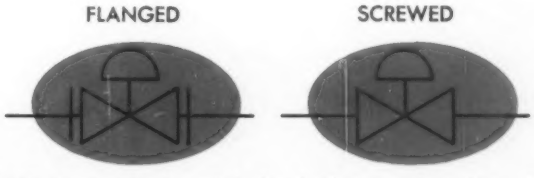


FIGURE 11—Graphical symbols for diaphragm valves, from ASA Z32.2.3-1949.[19]

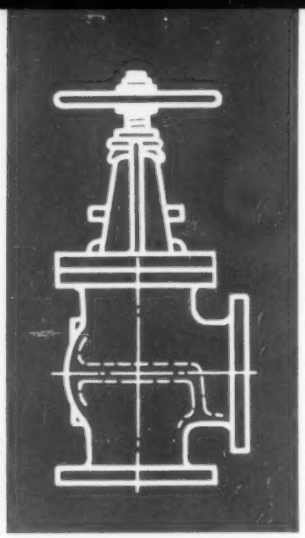


FIGURE 12 — Typical angle valve design, from ASA B16.5-1957.[2]

psi applications but give good service in 8- and 10-inch valve sizes.

Diaphragm Valves. This type of valve is excellent for throttling service in handling corrosive or toxic materials. Sulfuric acid service and water treating are examples. These valves are generally glass lined and are used with a fluorinated plastic diaphragm.

In HF alkylation service, the inner, thin, stainless steel diaphragms should be specified as monel to eliminate breakage.[10]

Sampling Valves. Bar stock needle valves have not been satisfactory in sampling service because of operator abuse in tightening the valve to such an extent that the seat was damaged. Globe valves have been affected the same way in sampling service as needle valves except that because they are sturdier they have lasted longer. Gate valves have been the most successful in the past although they are difficult to operate. Ball valves seem to hold the most promise in the field of sampling valves.

Slide Valves. This type of valve used for catalyst handling is generally changed every turnaround in a refinery and resurfaced. One refinery states that they have obtained six months extra service by using hard surfacing material instead of a 4-6 chrome slide. In fact, hard surfacing of slide valves is becoming the rule today but problems still exist in getting a good bond between the material and the slide.

Line Blind Valve. This type of valve is used where an absolute positive line shut-off upstream and downstream is required. These valves are used on transfer lines to storage areas, foam lines to storage tanks, fuel gas lines to furnaces and other locations where blinding is frequent.

One advantage of this valve is that the operator can change the blind in a matter of minutes and pipe fitters are not needed for blinding and removing blinds. In one application, a line blind valve was used on the inlet and outlet lines of cat poly reactors which enables the reactors to be unheaded starting at 8 a.m. instead of waiting from two to four hours to free the reactors. These blinds were the 900-pound series.

The greatest use of line blinds occurs on common tankage transfer lines and loading lines where leakage through valves might occur.

HF Control Valves. The inner valve parts of 18-8 stainless steel in HF acid service have been found to give very good operation. One valve on recycle acid service with a 11-13 chrome steel inner valve and stem was badly corroded. Because of stem corrosion in HF acid service, it is recommended that 18-8 stainless steel not be used but that monel stems or carbon steel stems be used.[10]

Safety Valves. There are two main types of safety valves used today: the relief valve and the "pop" valve. The relief valve is an automatic spring-loaded, pressure-relieving valve which is actuated by the static pressure under the seat which opens with an increase in pressure over the valve setting pressure. Its principal use is in liquid service.

The pop valve is an automatic spring-loaded, pressure-relieving valve actuated by static pressure under the seat and is characterized by a full opening or pop action at the set pressure. These valves are classified as "conventional" or "balanced" depending on the effects of back pressure on their performance. The conventional type pop valve is used where pressure is released to the atmosphere or to a low-pressure relief header. The balanced type pop valve is used where a relatively high pressure exists or is built up in the relief header.

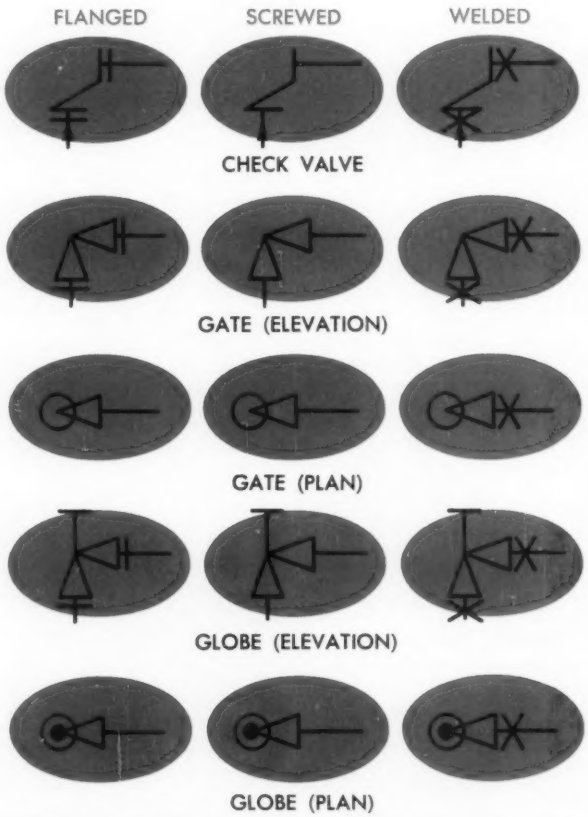


FIGURE 13—Graphical symbols for angle valves, from ASA Z32.2.3-1949.[19]

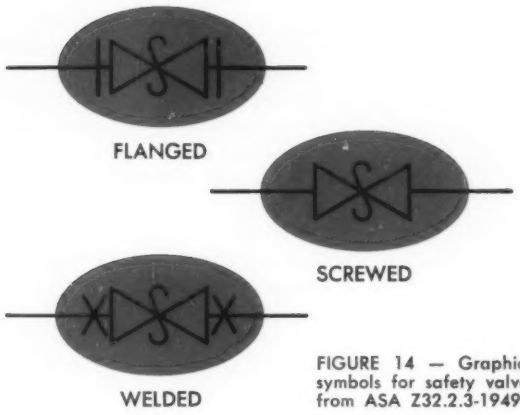


FIGURE 14 — Graphical symbols for safety valves, from ASA Z32.2.3-1949.[19]

Selecting a Safety Valve. The designer should ask himself the following questions: Should the valve be fully enclosed or should the spring be exposed? Should the valve be equipped with a lifting lever? If so, should it be the open type; or should it be packed?

Design tips for safety valves. The safety valves should be installed on a full-sized nozzle as close as possible to the equipment protected. If the pop type valve is used, it should be installed in the vapor space above the liquid. If the relief type valve is used, it should be installed in the liquid zone. These valves should be installed in a vertical position. If two or more safety relief valves are required and are installed on one connection, the cross sectional area of the section should be equal to the combined inlet of the safety devices connected to it. The discharge piping should never be less than the valve outlet size and should be so arranged that it will not exert excessive stresses on the safety valve body. Atmospheric discharge pipes on valves in hydrocarbon service should be provided with an adequate drain and snuffing stem connection. If the valve is discharged into a closed system, the back pressure should be checked as well as the capacity of the relief header. Be sure the valve is installed in a location where it is readily accessible for maintenance. Do not connect safety valves which are set to release at low pressure into systems in which high pressure safety valves discharge. Block valves should not be installed between the equipment protected and the safety device.

Check List for Relief Valve Specifications:[17]

- Manufacturer's catalog or figure number, if known.
- End type and size (flanged, screwed, and if flanged, raised face or ring type joint).
- Type of fluid being relieved and corrosivity (Manufacturer may supply steam relief valve if this is not specified).
- Pressure or vacuum to open.
- Set point required and adjusting range.
- Max. pressure and temperature.
- Trim required if other than standard.
- Volume of fluid to be handled under relief conditions.
- Lifting gear, if required.

Materials of construction

The term trim applied to gate valves generally refers to material from which the stem, disc faces and seats are made. In addition, certain other parts such as inside screw wedge bushings, bonnet bushings, yoke stem nuts and yoke wheel clamp nuts may be made of trim material.

API 600 defines trim as comprising:

- Body seating surfaces
- Wedge or disc seating surfaces
- Back-seat bushings or surfaces
- Stem

The standard (API 600) also specifies the following materials for trim parts:

- Cast (ASTM A351, Grade CA15)
- Forged (ASTM A182, Grade F6)
- Wrought (ASTM A276, Type 416 90.12 percent carbon max. or AISI Type 410)

The term trim applied to check valves refers to matrial used in the disc faces and seat faces. In addition, other parts such as clapper arms, clapper arm pins, disc stud nuts, cotters, and washers may be made of trim material.

Valve Stems. In selectiing the type of valve stem, the designer must ask himself whether it is more important for the operating position of the valve to be observed by the operator than is less maintenance cost or zero leakage through the stem. The rising-stem gate valve contains a valve stem that slides only. The rising-stem globe valve has a stem that turns and slides. The plug valve stem turns only. The rising-stem types insure ease of noting the operating position of the valve, and are recommended in ASA B31.1 for valves sized 2½-inch and larger. However, because a part of the stem is alternately exposed to the process fluid or the atmosphere and moved into the packing gland, it would require more maintenance than a stem which rotates only. Threads inside the body, however, increase maintenance in corrosive or high-temperature services. A bellows or diaphragm valve is usually required for high vacuum or other services where zero leakage is necessary.

Note: API 600 requires stems to be of wrought material with a min. hardness of 200 Brinell.

Gate Valve Bonnet. There are three main types of valve bonnets. The screwed-in bonnet is the cheapest type but is also the least reliable because tight sealing of the stem requires that the bonnet be screwed strongly against the neck which often causes distortion. The bolted-flanged bonnet contains a large stuffing box and a bolted packing gland. This design is the most rugged of the three bonnet types and, therefore, is used for

most of the larger process unit gate and globe valves. This valve is also usually installed with flanged ends. The third type of bonnet design is called the union bonnet and is a fairly simple design for repeated disassembly and reassembly of the valve. Fluid pressure acts to seal the joint very tightly.[9]

Note: API 600 requires a considerably higher min. wall thickness for valve bodies and bonnets than does ASA B16.5 (as much as ⅛ to ¼ inch). This is an additional corrosion allowance.

Operators. The use of a rack and pinion operated valve or worm gear operated valve instead of lever is suggested for valve operation in propane service where the valve is three inches and larger or, as a matter of fact, any service in which there is a substantial pressure differential across the valve in the closed position.

Ductile Iron. The first ductile iron valves did not comply with API standard 600 but did meet ASA B16.5. Many petrochemical plants and some refiners are now interchanging ductile iron valves with steel valves with a temperature service limit of 600° F. The industry has agreed to an 80 percent rating on ductile iron valves which is based on a Navy evaluation. Therefore, ductile iron valves are good for 80 percent of the ASA rating **only**. Generally, these valves are made only in 150-pound series at the present time. Therefore, ductile iron valves could be applied only to 120-pound service or less. One big advantage noted for ductile iron valves is that the price is about 80 percent of steel valves.

Some refiners are still very concerned about the safety hazard of ductile iron valves. They feel that during a fire there is a possibility that the valve would break like cast iron when cold water is poured on the valve. Another problem is in being sure you, in fact, get ductile iron when it is specified. The only solution at present is to pick a reliable supplier.

A good point cited for ductile iron valves is that they operate very satisfactorily in sulfuric acid service.

Glass-Lined Valves. For temperature resistance to 350° F, glass-lined valves have beensuccessfully used. The temperature rating should be limited to about 212° F or high pH fluids. Small sized valves can't be glass-lined because an 8-inch radii is required.[11]

Valve Ends. For process piping, flanged-end valves are used most generally because they provide a strong, leak-proof joint even though they are more costly than a screwed-end valve. The latter may be rapidly installed in small sizes (less than 3-inch) however, they are always a potential source of leakage.[9] Bell-and-spigot joints are available on valves and are used on underground cast-iron water lines. The rating of fittings and valves can be stated as falling in these following general categories, (a) low pressure—25 psi, (b) standard—125 psi, (c) extra heavy, 250 psi and hydraulic 300 to 10,000 psi.

Welding-end Valves are used for special cases where leakage is prohibited or as one refiner puts it, if the valve is not replaced more often than every three to five years. Considerable savings in valve cost can be had considering weld-end valves replacing flanged or screwed-end types. Generally these valves have been used in a few steam services, especially on large sizes, but most refiners are timid about applying them in hydrocarbon service. A good rule of thumb is to consider weld-end valves for services where the valve body is not removed every two years or more. It would probably be safe to say that if the line must be cut once every two years and the valve welded back during a turnaround operation, the cost would not be much greater than unbolting, regasketing, and reassemblying.

Valve Flanges. A trend seems to be in the direction of using raised-faced flanges and suitable gaskets for most process area applications. Some companies have abandoned ring-type joints entirely and are successfully using raised facing up to and including the 1500-pound series. The problem with raised-faced flanges on valves in the past has been leakage in 300-pound series and above. Therefore, some refiners have required ring-type joints in 300-pound service and up. Others set their limit at 600-pound series and up.

Gaskets. Compressed asbestos ring type gaskets may be specified for the following typical services and operating conditions:[9] hydrocarbon (100 psi and 600° F), exhaust steam (40 psi and 290° F), steam condensate (15 psi and 240° F), air at 50 psi and 100 psi and ambient temperature, natural gas at 50 psi and ambient temperature, and water (fire, process, utility and sanitary) at 100 psi and ambient temperature.

For severe services such as hydrocarbon at 250 psi and 750° F (Max.) and 275 psi steam at 410° F, corrugated metal, double jacketed, asbestos filled gaskets should be used.

For hydrocarbon service at 250 psig and 800° F (Max.) ring-type joints are sometimes used requiring a ring gasket.

The ASA standard on gaskets that apply most specifically to valves, is ASA B16.5-1957, Appendix E, Gasket Group I.[2]

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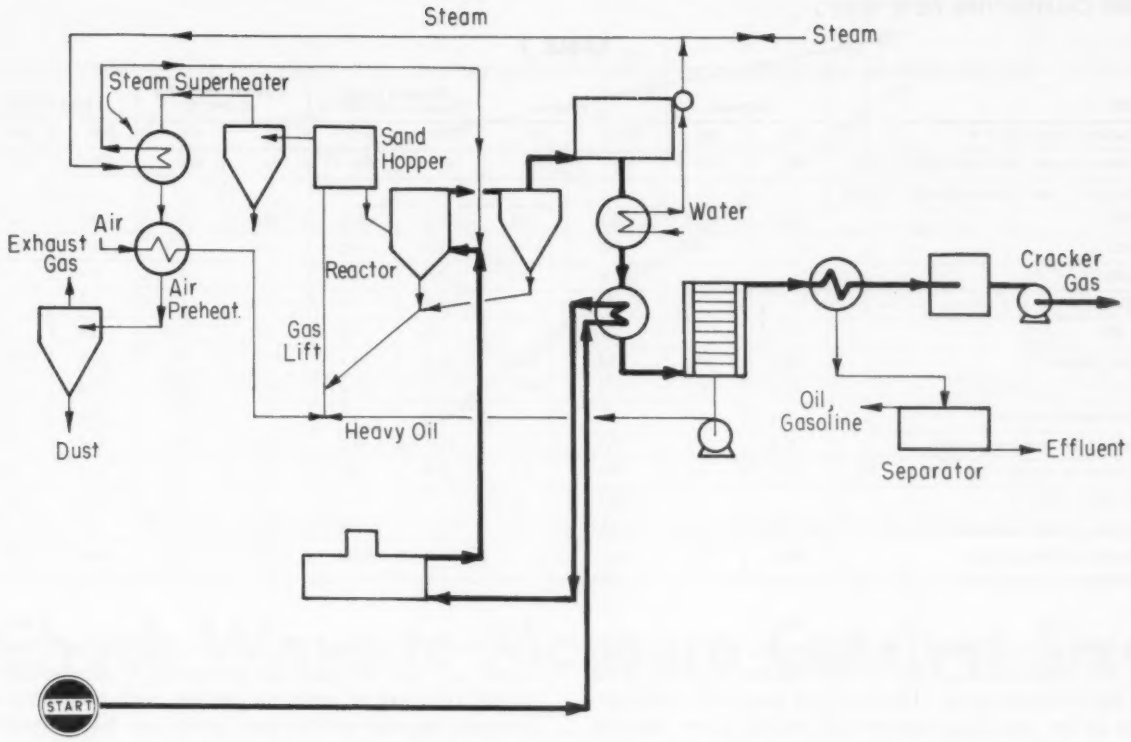

This Lurgi-Ruhrgas sand cracking process produces a wide range of olefins using most any hydrocarbon feed stock.

Make Olefins This New Way

Lurgi-Ruhrgas sand cracker produces mono-olefins and aromatics from stocks ranging from ethane through residual oils. Extremely flexible, propylene: ethylene ratios may vary economically between 0.3 and 0.9

Lurgi Gesellschaft fur Warmetechnik, m.b.H.
Frankfurt (Main), Germany

Charging stocks ranging from ethane to residual oil, the Lurgi-Ruhrgas sand cracking process produces a wide range of olefins. Flexibility and range of operating conditions permit variations of product distribution. It is possible to vary propylene:ethylene ratio from 0.3 to 0.9 under economic conditions.

Application: Production of ethylene, propylene, higher mono-olefins and aromatics from hydrocarbons.

Charge: Crude oil or any mineral oil product from ethane to residual oil, including liquefied gas, light naphtha and heavy distillates.

It is advisable to distill crude oil, or residual oil with a high coking residue, before cracking to remove asphalt.

By varying the feedstocks to meet the changing market conditions, refiners can approach the optimum utilisation of their products at all times.

Products: Ethylene, propylene, iso- and normal butylenes, butadiene, cracked gasoline, aromatic hydrocarbons (benzene, toluene, xylenes) naphthalene; methane and hydrogen and other secondary gases.

The flexibility of the process and the available range of operating conditions permit variations of product distribution. It is possible to change the propylene to ethylene ratio within a range between 0.3 and 0.9 under economic conditions.

Description: The process is a combination of the turbulent-layer and fluid-bed techniques. The heat carrier for the cracking reaction is hot, fine-grained sand which is given a swirling motion by the hydrocarbons and steam injected, thus transferring its heat to the hydrocarbons and effecting the cracking. The sand is continuously withdrawn and pneumatically returned to the cycle.

The feed is heated to 300-400° C by waste heat avail-

TABLE 1

FEED	Ethane		Propane		Kuwait Light Naphtha 40-100° C		Kuwait Naphtha 50-160° C		Iraq Crude	
Cracking temperature °C	820	850	770	825	775	830	825	850	730	760
Volume of gases produced Nm^3/t of feed	1200	1255	890	980	760	935	785	880	505	555
Analysis of gases produced-weight percent	....	....	....	....	....	....	....	....	....	....
C_2H_4	52.6	56.6	26.0	39.2	28.2	36.8	32.6	36.0	19.6	23.1
C_3H_6	....	2.0	15.1	12.0	17.0	15.2	14.1	8.9	12.6	12.8
C_4H_6	....	....	1.8	2.2	2.0	2.5	4.0	3.5	3.4	3.7
nC_4H_8	....	1.4	1.4	1.6	3.7	1.3	0.6	0.2	2.4	0.8
iC_4H_8	....				2.5	1.5	1.6	0.8	2.3	1.2
Total olefines	52.6	60.0	44.3	55.0	53.4	57.3	52.9	49.4	40.3	41.6
Total C_1—C_4 paraffins	39.4	28.1	51.2	39.3	21.5	27.2	20.4	23.1	13.8	14.4
Total secondary gases	6.4	6.3	1.7	3.1	2.4	4.1	3.0	3.9	3.4	2.4
Grand total of gases produced	98.4	94.4	97.2	97.4	77.3	88.6	76.3	76.4	57.5	58.4
Gasoline up to 200° C	1.0	5.1	2.2	2.0	22.2	10.9	7.5	16.3	17.0	16.5
Oil above 200° C	....	....	0.1	....	....	....	5.7	6.8	20.5	22.1
Carbon on sand and losses	0.6	0.5	0.5	0.6	0.5	0.5	0.5	0.5	5.0	3.0
Grand total of products	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

able from the process and by a preheater, and blown into the hot, fluidized sand bed of the reactor, together with the superheated steam. The hot sand heats the hydrocarbons to the cracking temperature which is set between 700 and 850° depending on the nature of the feedstock and the desired propylene to ethylene ratio. The cracking temperature is kept constant within narrow limits and the time of reaction ranges between 0.3 and 0.5 seconds. The heat consumption of the cracking process reduces the temperature of the sand by about 100° C.

The cracked gases leaving the fluid bed will be quenched in a heat-exchanger, freed from entrained sand fines in a cyclone, precooled in a waste-heat boiler for heat efficiency, and then cooled in a heat exchanger for preheating the feedstock and the feedwater for the waste heat boiler to about 150° C. A mist of heavy oil is separated, water-free, in an electrostatic precipitator. The electrostatic precipitator is not required in cases, where the final boiling-point of the hydrocarbons treated does not exceed 200° C. The cracked gases pass through an indirect cooler and a mist extractor and to further treatment. Water and middle oil are removed in the indirect cooler and separated from each other in a separating tank.

The cracked gases are separated by low temperature fractionation.

In the reactor, the sand is coated with coke from the cracking. The sand is continuously withdrawn from the fluid bed, pneumatically conveyed by hot combustion gases through the sand lift into the sand bin and thereby heated up. The lift gases are generated by combustion of fuel oil, or heavy oil from the process, with preheated air. The coke deposits on the sand grains are burnt away by a controlled small amount of surplus air, which regenerates the sand. The hot carbon-free sand separates from the lift gases in the bin and flows back into the reactor. The exhausted lift gases are dedusted in a cyclone and subsequently used for superheating the process steam and the conveying air.

TABLE 2

	When Treating Hydrocarbons	
	Light	Heavy
Fuel oil (residual oil) ..... kgs.	300	450
Electric power ..... kwh.	70	120
Process steam (generated from waste heat: 0.8—0.9 t) ..... ton	0.4	1.5
Cooling water ..... m^3	60	100
Sand (0.4—1.2 mm. particle size) ..... kgs.	80	100

Operating Conditions: A wide range of flexibility allows conditions to be tailored to any feedstock and desired products by changing the cracking temperature and the time of reaction. The load can be reduced to less than 40 percent. The limit is given by the gas separation plant. Cracking temperature up to 850° C. Pressure: up to 500 mm W.G.

Yields:

Utilities per ton of C_2 to C_4 olefins:
Present maximum capacity of one unit:

Feed	Yield of ethylene tons/year	Yield of C_2-C_4 olefins tons/year
Ethane	70,000	70,000
Propane	60,000	85,000
Light naphtha	60,000	95,000
Straight-run naphtha	50,000	80,000
Crude oil	35,000	60,000

Commercial Installations: One in operation at Dormagen, Germany; four under construction (2) at Merseburg, Germany, (1) at Chiba, Japan, and (1) at Rosario, Argentina.

Key Words for Indexing

Butadiene
Butylenes
Cracking/chemical
Ethylene
Olefins
Propylene

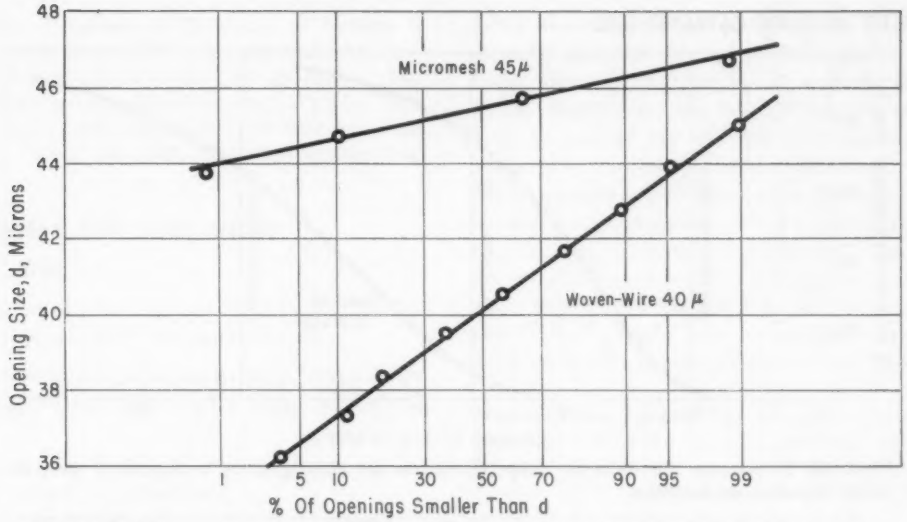

FIGURE 1—Micromesh sieves possess very uniform openings with only small variations in size.

Check Ways to Measure Catalyst Size

Here is a critical examination of ways to measure true particle size distribution. Now you can see why different methods give different results and why one method is recommended as better than the others

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After studying ways to measure the true particle size distribution of catalyst, these conclusions were reached:

Woven-wire screens have very irregular openings, must be calibrated regularly and are reliable only in the range larger than 40 micron, which makes it necessary to supplement the data with those from another method in the subsieve range. As a result of the microscopic measurements the largest sieve openings can be considered as the effective openings. Then, the results closely agree with those of micromesh sieves.

Hydrometer-sedimentation is carried out with calcined catalyst and cannot be compared with data of non-calcined material. Moreover, the results in the range larger than 50 micron have little reliability; combination with other methods is necessary; results from the sedimentation correspond to those from sieving calcined catalyst with micromesh sieves.

CAE-Roller method shows considerable differences from other methods. This phenomenon is caused by the short separation-time and calculating the results with empirical factors.

Cascade-Roller results correspond to micromesh data. However, the method produces insufficient data for a complete particle size determination.

Micromesh sieves have little variation in size of openings for which reason the average opening can be taken as the effective opening; have uniformly shaped openings; have screens with size of openings covering the whole range of interest: from 10-150 micron; yield results with great accuracy and reproducibility; have the advantage that, once calibrated, no complicated calculations and corrections have to be made and offer a shorter time of analysis.

WHAT PROMPTED THE STUDY

The particle size distribution of cracking catalyst is most important for proper fluidization in the unit. In the past a number of methods have been developed and adopted for determination of the particle size distribution. Each of these methods shows disadvantages, and the results obtained with one method often differ considerably from those with other methods, which has made comparison of particle size data difficult. At the Ketjen Laboratories various of these particle size distribution methods are in use for production-control of fresh catalyst and service-testing of equilibrium catalyst for the refineries.

Some years ago there were introduced micromesh sieves containing electroformed screens which show a better uniformity of the meshes than woven wire screens. These are available with openings from 10-150 microns, offering the possibility to cover the whole range of interest with

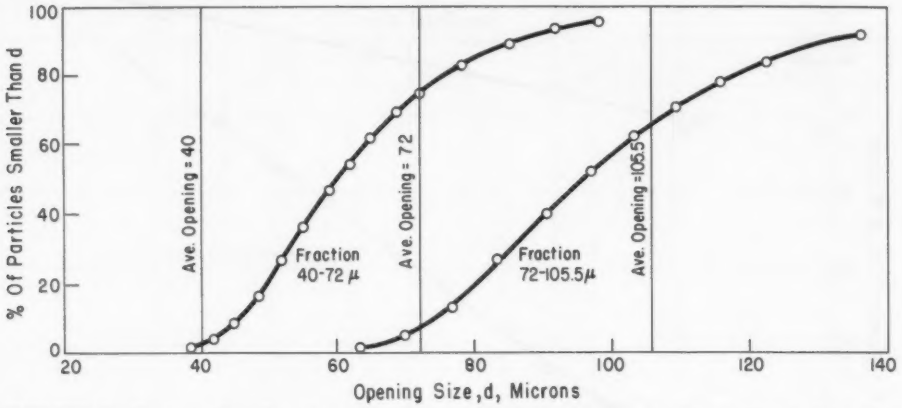

FIGURE 2—Because the diameter perpendicular to the plane can not be measured, these distribution curves are incorrect.

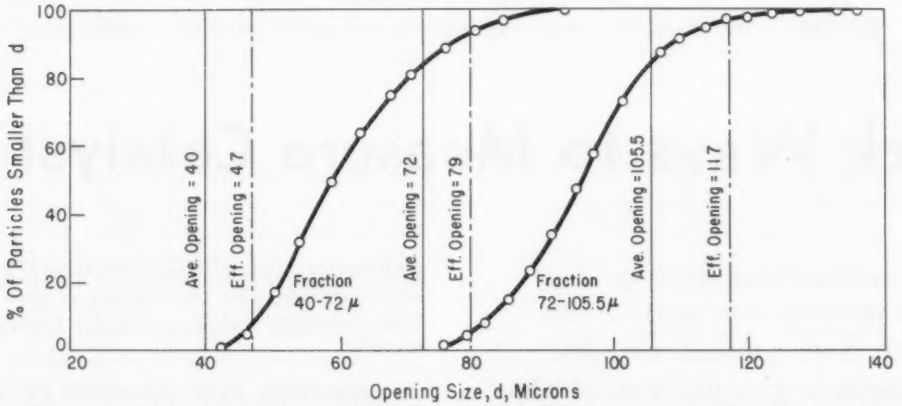

FIGURE 3—Geometrical ideal spherical catalyst give data which show effective size is greater than the average size.

enough data. Interesting investigations on the properties of these micromesh sieves have been made by Daeschner et al.[1] In their publication they describe the differences between particle size data obtained by micromesh sieves and the data obtained with other methods. However, a proper explanation for these differences was not given.

To find the cause of these discrepancies was one of the motives for this investigation which ultimately led to a critical examination of the micromesh sieves-method in comparison with various other methods. It is concluded that the particle size data obtained with micromesh sieves as compared with other methods are more exact, more accurate, cover the entire range of interest and imply a considerable simplification of the particle size determination. Even though the sieves from some manufacturers are not as satisfactory as those reported here, the data show the degree of separation which can be achieved.

HOW THE TESTS WERE MADE

In this investigation the following methods have been evaluated and compared using one sample fresh and one sample equilibrium synthetic fluid cracking catalyst:

ASTM-woven wire sieves.[2] A sample of 35 grams of catalyst is mixed with water to about 30% moisture and shaken on a sieve shaker for 20 minutes, using ASTM-woven wire sieves of 100, 140, 200 and 325 mesh.

Micromesh sieves.[3] A sample of about 1 gram of catalyst is exposed to the surrounding atmosphere for 25 minutes. After weighing each sieve and the sample to the nearest milligram, the sample is shaken for 30 minutes on an adapted sieve shaker. Then, after weighing each sieve the operation is repeated for periods of 5 minutes until the differences between two weighings are less than 2mg.

Hydrometer Sedimentation.[4] A sample of 22 grams of catalyst, after having previously been dried for 1 hr at 600°C, is mixed with isopropyl alcohol (sp. gr. 0.778) to a total volume of 550 ml. and separated by sedimentation at a temperature of (30 ± 0.1)°C. The concentration as a function of the sedimentation is determined by a suitable hydrometer.

CAE-Roller.[5] A sample of 7 grams of catalyst is conditioned for 2 hrs in an atmosphere of 60% relative humidity. It is elutriated for 20 minutes in each of the settling chambers of 9", 4½", 2¼", 1⅛" internal diameter, at an air rate of 9.0 liters/min. A sample holder with fritted disc is used. True sizes are calculated with the Kellogg density and the corrections normally applied in this method.

Cascade-Roller. A sample of 10 grams of catalyst is mixed with water to about 30% moisture and elutriated for 1½ hours in the Cascade-Roller apparatus. The apparatus contains settling chambers of 4½", 2¼" and 1⅛", the air rate is 9.6 liters/min. The true sizes are calculated using Stokes' law with corrections for the drag coefficient.

WHAT THE TESTS SHOW

Assumptions Made.

- The nominal size of a sieve is considered to be the size of sieve-openings, given by the manufacturer.
- The average size of a sieve is the average, obtained by microscopic measurement of a large number of openings.
- The effective size of a sieve is derived from particle size measurements of the fractions.

For woven wire sieves as well as for micromesh sieves, normally the average size of the openings is considered as the effective sieve opening. To examine the correctness of this supposition, the average size of openings of the sieve, as well as the effective sieve opening, was determined by microscopic measurements.

The average size of openings of a screen was measured by taking micrographs of 140 sieve-openings at a suitable magnification at random positions of the screen. The woven wire sieves show openings of highly irregular shape and widely varying size. On the contrary, micromesh sieves possess very uniform openings with only small variations in size (Table 1 and Figure 1).

Woven-Wire Sieves. The effective sieve openings were determined with the aid of microscopic measurement of fractions obtained by sieving a catalyst sample. For this purpose, 700 catalyst particles of each fraction were

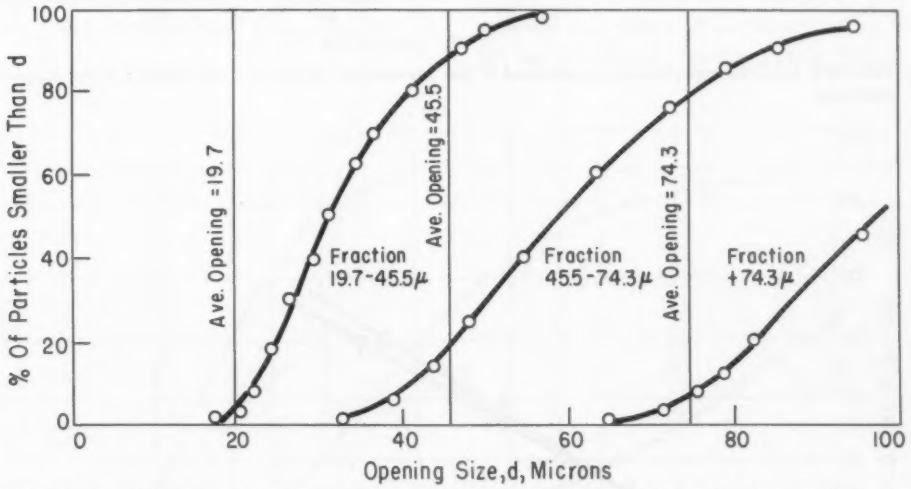

FIGURE 4—Here are data for a synthetic fluid cracking catalyst through micromesh sieves.

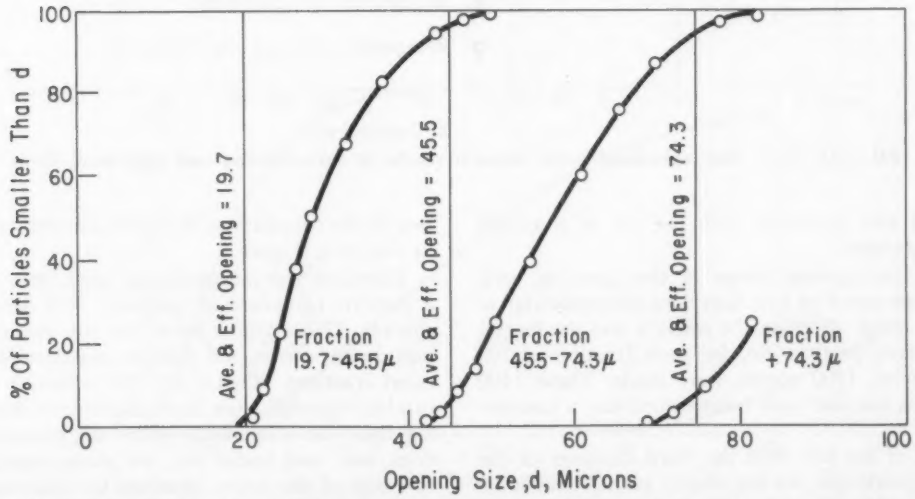
% Of Particles Smaller Than d
Ave. B Eff. Opening = 19.7
Ave. B Eff. Opening = 45.5
Ave. B Eff. Opening = 74.3
Fraction 19.7-45.5μ
Fraction 45.5-74.3μ
Fraction +74.3μ
Opening Size, d, Microns

FIGURE 5—Effective sizes of micromesh sieves can be considered as being same as average sizes.

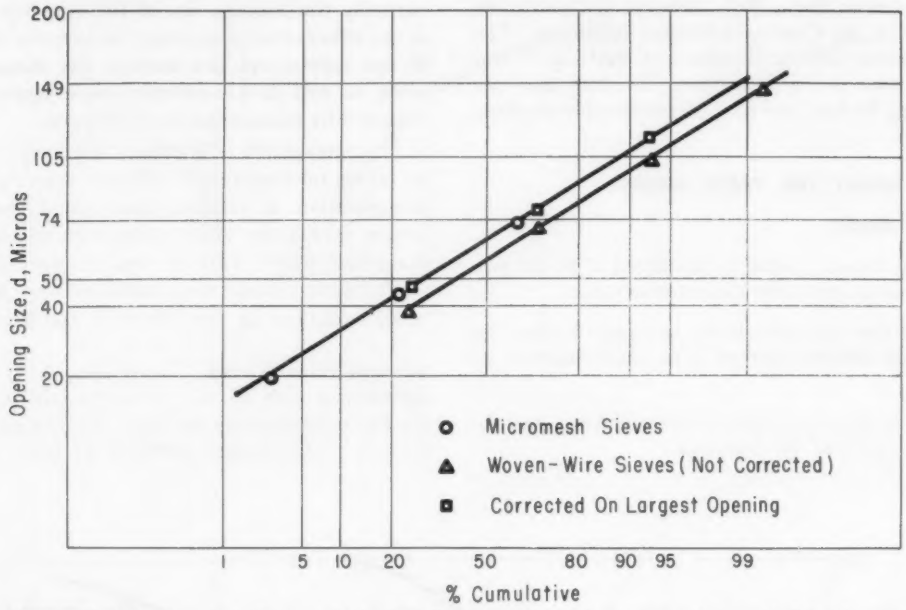

FIGURE 6—Different results are obtained if the woven-wire sieves are not corrected for largest openings.

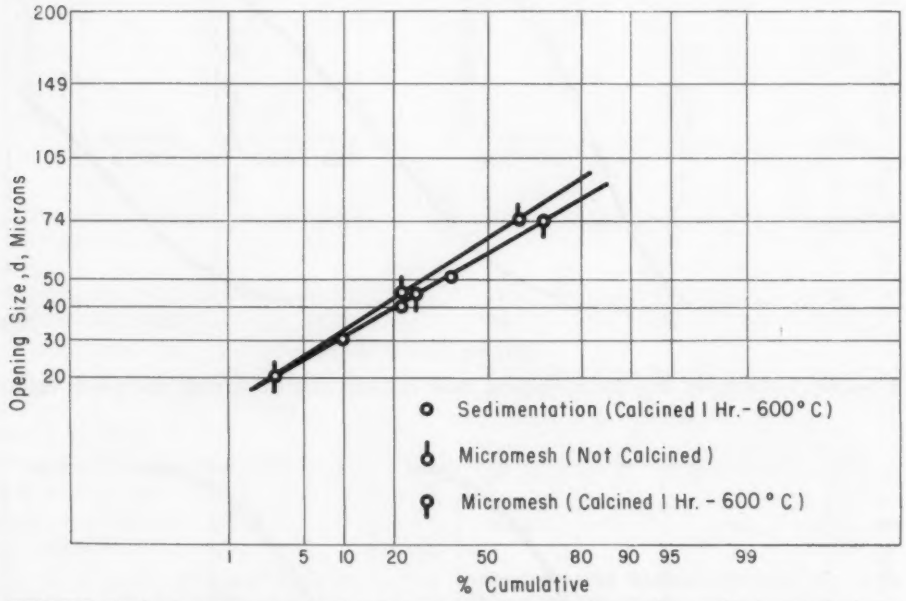

FIGURE 7—A close agreement exists between results of sedimentation and micromesh sieves.

photographed and measured with the aid of a special particle-size-analyzer.[6]

Because of the egg-like shape of the particles, each particle was measured in two directions perpendicular to each other in order to obtain the smallest and the largest diameter of each particle. So, for each fraction of 700 counted particles, 1400 counts were made. These 1400 counts for each fraction were transformed into a cumulative curve.

As a result of the fact that the third diameter of the particles, perpendicular to the object plane, cannot be measured with the microscope, there is some incorrectness in the calculations of the obtained distribution curves as shown in Figure 2.

Therefore the measurements have been repeated with a catalyst composed of particles with geometrical ideal spheres. These curves show that the average sieve openings do not correspond with the distributions of the separated fractions (Figure 3). The effective sieve opening can be estimated from these distribution curves by choosing those sieve openings where the percentages of fractions over and under size are about equal. The largest openings of the sieves, obtained by microscopic measurements, come up to this requirement. Consequently, if the

sieve action is complete, the largest openings of the sieve have determined the size of particles retained or passing through.

Micromesh Sieves. As stated before, there is some incorrectness in the obtained distribution curves of fluid cracking catalyst fractions, obtained by microscopy, due to the non-ideal spherical form of the particles (Figure 4). Also for the micromesh sieves we used a catalyst with geometrical ideal spheres. These distribution curves show that only a small percentage of the fractions is over and under average sizes of the sieves, (Figure 5), so that it can be concluded that the average sizes of these micromesh sieves can be considered as the effective sizes. Contrary to the woven-wire sieves, it would not be necessary to correct the micromesh screens for the largest openings.

Measuring the particle size distribution of a synthetic fluid cracking catalyst with woven-wire sieves and micromesh sieves, different results are obtained if the woven-wire sieves are not corrected for largest openings (Tables 2 and 4); if corrected the results correspond well (Figure 6). Moreover, the micromesh sieve method produces data with great accuracy and reproducibility (Table 4).

TABLE 1—Screen Opening in Woven-Wire Screens and Micromesh Screens

Sieve Type	MICRONS				
	Mesh Size	Nominal Size	Average Size	S	Largest Opening
Woven Wire.....	140	105	105.5	±3.5	116.9
Woven Wire.....	200	74	72.2	±2.0	78.8
Woven Wire.....	325	44	40.2	±2.2	47.2
Micromesh.....	...	75	74.3	±1.2	76.9
Micromesh.....	...	45	45.5	±0.6	47.2
Micromesh.....	...	20	19.7	±0.5	21.2
Micromesh.....	...	10	9.9	±0.2	10.6

Hydrometer-Sedimentation. By coincidence the results of the hydrometer-sedimentation of calcined catalyst (1 hr.-600°C) correspond more or less with the results of woven-wire sieves sieving non-calcined catalyst if these sieves are not corrected for largest openings. However, due to calcination the catalyst particles show a shrinkage in all directions of about 13% as measured from micrographs. To check the sedimentation results, a fresh catalyst sample was calcined 1 hr. at 600°C and analyzed by micromesh sieves. Figure 7 shows a close agreement between the results of sedimentation and micromesh sieving of calcined material (Table 5).[3]

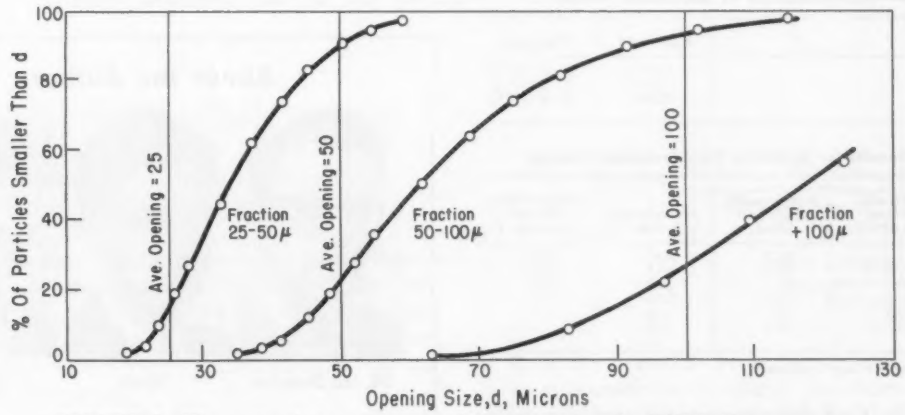

FIGURE 8—The separation was not complete when using the CAE-Roller apparatus.

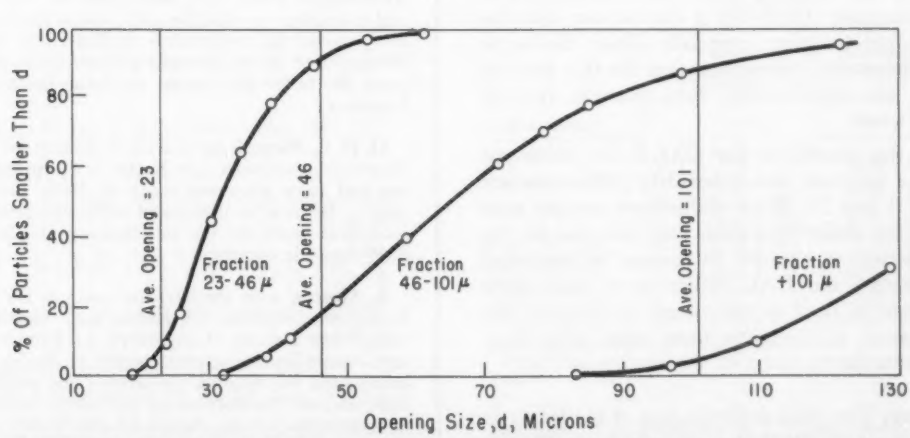

FIGURE 9—The Cascade-Roller analysis gives good separation of larger and smaller particles, although a combination with other methods is generally needed.

TABLE 2—Particle Size Distribution for Fresh Synthetic Fluid Cracking Catalyst

Size, Microns	Woven Wire Sieves		Cascade Roller	CAE—Roller	Micromesh Sieves
	Avg.[a]	Corr.[b]			
—149	99.3	98.8	....	....	....
—105	92.3	88.3	....	....	....
— 74	70.5	61.5	59.5	57.5	61.5
— 70	66.0	56.5	54.0	51.5	56.0
— 50	39.5	29.5	27.0	21.7	28.0
— 45	32.0	23.0	21.5	16.5	22.1
— 40	25.0	17.5	16.3	12.0	17.0
— 30	....	....	8.3	5.7	8.1
— 20	....	....	3.4	2.4	3.0

[a] Based on average openings in screen.
[b] Corrections based on largest openings in screen.

TABLE 3—Particle Size Distribution for Equilibrium Synthetic Fluid Cracking Catalyst

Size, Microns	Woven Wire Sieves		Sedimentation	Cascade Roller	CAE—Roller	Micromesh Sieves
	Avg.[a]	Corr.[b]				
—149	99.6	99.4	....	....	....	....
—105	98.5	97.8	....	....	....	....
— 74	92.8	89.0	....	94.4	92.2	90.0
— 70	90.8	85.5	....	90.4	86.0	87.0
— 50	61.0	46.0	50.0	41.5	27.5	50.0
— 45	45.0	....	37.0	27.5	15.0	35.4
— 40	26.2	....	23.0	15.7	7.2	22.0
— 30	....	....	3.9	3.2	1.0	4.3
— 20	....	....	0.75	0.4	0.8	0.1

[a] Based on average openings in screen.
[b] Corrections based on largest openings in screen.

TABLE 4—Reproducibility of Micromesh Sieves

Sieve, Microns	S (n = 10)	Precision
74	0.355	X ± 0.8 %
45	0.318	X ± 0.7 %
20	0.134	X ± 0.27%

TABLE 5—Results for Synthetic Fluid Cracking Catalyst

Size, Microns	Sedimentation (1 hr 600 °C)	Micromesh (non-calcined)	Micromesh (1 hr 600 °C)	Woven Wire Sieves[a] (1 hr 600 °C)
—74	....	61.5	69.5	69.0
—50	37.4	28.0	34.5	34.0
—45	30.0	22.1	26.0	27.0
—40	21.9	17.0	21.5	....
—30	9.8	8.1	9.8	....
—20	3.1	3.0	3.2	....

[a] Based on largest opening in screen.

CAE-Roller. The CAE-Roller apparatus used was modified with a fritted metal disc, to avoid attrition of the particles during the analysis. From the distributions of the obtained fractions (Figure 8) it can be seen that the separation was not complete, especially where the larger particles are concerned. An explanation for this may be that the time for separation of each fraction (i.e. 20 min.) is insufficient.

Comparing the results of the CAE-Roller with the results of other methods, considerable differences are found (Tables 2 and 3). These differences are not only caused by the too short separation time but also by the way of calculating the results by means of empirical factors.[7] Moreover, the CAE Roller gives only three (max. four) sets of data in the range of interest; this makes it necessary to complete these data with those from other methods.

Cascade-Roller. The plotted distribution of the fractions obtained with the Cascade-Roller analysis shows a good separation of larger and smaller particles (Figure 9). Comparing the results of the Cascade-Roller with those from other methods, it must be remarked that no complete particle size distribution can be obtained as only three or four data are available in the range of interest. Though these data are fairly accurate, combination with other methods is generally necessary, especially when used catalysts are analyzed (Tables 2 and 3).

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Thermo Data for Petrochemicals

Part 32: Symmetrical Dithia Alkanes. The important thermo properties are presented for all gaseous symmetrical dithia alkanes up to 20 carbon atoms

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Heat of formation. Heats of formation of 2,3 dithiabutane,[1] 3,4 dithiahexane[1] and 4,5 dithiaoctane[1] are given in the literature. These values were calculated from measured heats of combustion. In order to bring the data in line with a recent redetermination[2] of the heat effect of the reaction

$$S(rh) + 56\,H_2O(l) + \frac{3}{2}\,O_2(g) \rightarrow H_2SO_4 \cdot 55\,H_2O(l)$$

the literature values were slightly corrected. The heats of formation at 25 °C thus found are given in Table 1.

If we calculate the heat effect ΔH_r° for the reaction

$$(C_nH_{2n+1}S)_2(g) + H_2(g) \rightarrow 2\,C_nH_{2n+1}SH(g)$$

we get at 25 °C

$$CH_3-S-S-CH_3 : \Delta H_r^\circ = -5.19 \pm 0.32 \ \frac{kcal}{mole}$$

$$C_2H_5-S-S-C_2H_5 : \Delta H_r^\circ = -4.74 \pm 0.36 \ \frac{kcal}{mole}$$

$$C_3H_7-S-S-C_3H_7 : \Delta H_r^\circ = -4.50 \pm 0.38 \ \frac{kcal}{mole}$$

By extrapolation of these values we find for $n > 3$ a constant heat of reaction at 25 °C, i.e. $\Delta H_r^\circ = -4.50 \pm 0.38 \ \frac{kcal}{mole}$ $(n > 3)$. With this value of the heat of reaction we may write at 25 °C

$$\Delta H_f^\circ{}_{(C_nH_{2n+1}S)_2} = \underbrace{19.92 + 2\,\Delta H_f^\circ{}_{C_nH_{2n+1}SH}}_{\text{Reference state S(rh)}}$$

$$= \underbrace{4.50 + 2\,\Delta H_f^\circ{}_{C_nH_{2n+1}SH}{}^*}_{\text{Reference state } S_2(g)}$$

With the formulas given above we calculated the heats of formation of the higher homologs of the gaseous dithia alkanes, the results are presented in Table 1.

TABLE 1

Dithia Alkane		Reference State S(rh) ΔH_f° 298.15 °K kcal/mole	Reference State $S_2(g)$ ΔH_f° 298.15 °K kcal/mole	Literature
CH_3-S-S-CH_3	(l)	−14.93 ± 0.20	.....	1
	(g)	− 5.75 ± 0.20	− 36.59 ± 0.25	1
C_2H_5-S-S-C_2H_5	(l)	−28.48 ± 0.24	.....	1
	(g)	−17.62 ± 0.25	− 48.46 ± 0.29	1
C_3H_7-S-S-C_3H_7	(l)	−40.82 ± 0.24	.....	1
	(g)	−27.88 ± 0.26	− 58.72 ± 0.30	1
C_4H_9-S-S-C_4H_9	(g)	−38.34 ± 0.31	− 69.18 ± 0.35	Inaccuracy estimated
C_5H_{11}-S-S-C_5H_{11}	(g)	−48.38 ± 0.36	− 79.22 ± 0.40	
C_6H_{13}-S-S-C_6H_{13}	(g)	−58.14 ± 0.41	− 88.98 ± 0.45	
C_7H_{15}-S-S-C_7H_{15}	(g)	−68.00 ± 0.46	− 98.84 ± 0.50	
C_8H_{17}-S-S-C_8H_{17}	(g)	−77.86 ± 0.51	−108.70 ± 0.55	
C_9H_{19}-S-S-C_9H_{19}	(g)	−87.71 ± 0.56	−118.55 ± 0.60	
$C_{10}H_{21}$-S-S-$C_{10}H_{21}$	(g)	−97.57 ± 0.61	−128.41 ± 0.65	

* The heats of formation of the gaseous n-1 alkyl thiols were taken from Part 30.[3]

Entropy. The entropies of 2,3 dithiabutane,[4] 3,4 dithiahexane[5] and 4,5 dithiaoctane[1] are presented in Table 2.

TABLE 2

Dithia Alkane		$S°_{298.15}$ cal / mole °K	Literature
CH_3-S-S-CH_3	(l)	56.26 ± 0.10	4
	(g)	80.54 ± 0.30	4
C_2H_5-S-S-C_2H_5	(l)	72.90 ± 0.15	5
	(g)	99.07	5
C_3H_7-S-S-C_3H_7	(l)	89.28 ± 0.10	1
	(g)	118.30	1

THERMODYNAMIC PROPERTIES AS A FUNCTION OF TEMPERATURE

2,3 Dithiabutane and 3,4 dithiahexane

Thermodynamic data of these compounds were measured and calculated by the U.S. Bureau of Mines thermodynamics group.[1, 4, 5]

The values thus found are given in the Tables 3, 4, 5 and 6.

4,5 Dithiaoctane and higher homologs

The thermodynamic properties were calculated using a normal method of increments, i.e.

$$\phi[(C_nH_{2n+1}S)_2] = \phi[(C_2H_5S)_2] + 2\,\phi(C_{n+1}H_{2n+4}) - 2\,\phi(C_3H_8)$$

The values thus calculated are given in the Tables 3, 4, 5 and 6. If one compares the calculated entropy of 4,5 dithiaoctane at 298.15 °K with the measured one (Table 2) one finds a perfect agreement.

HEAT OF FORMATION AND FREE ENTHALPY OF FORMATION

Combining values of $\frac{H° - H_o°}{T}$ and $\frac{G° - H_o°}{T}$ given in the Tables 4 and 5 with the corresponding functions of C (graphite),[6] H_2 (gas)[6] and S_2 (gas),[7] and using the

Table 3

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Heat Capacity $C°_p$ cal / mole °K										
CH_3-S-S-CH_3	0	21.59	22.54	22.61	26.36	29.80	32.82	35.41	37.66	39.60	41.31
C_2H_5-S-S-C_2H_5	0	32.01	33.78	33.91	40.90	47.08	52.24	56.57	60.19	63.30	65.97
C_3H_7-S-S-C_3H_7	0	42.8	45.2	45.4	55.0	63.7	71.1	77.3	82.5	87.0	90.8
C_4H_9-S-S-C_4H_9	0	52.9	56.1	56.3	68.9	80.2	89.8	97.8	104.6	110.4	115.4
C_5H_{11}-S-S-C_5H_{11}	0	63.2	67.0	67.3	82.8	96.7	108.5	118.4	126.8	133.9	140.1
C_6H_{13}-S-S-C_6H_{13}	0	73.4	78.0	78.3	96.6	113.2	127.1	138.9	148.9	157.4	164.8
C_7H_{15}-S-S-C_7H_{15}	0	83.7	88.9	89.3	110.5	129.7	145.8	159.5	171.0	180.9	189.4
C_8H_{17}-S-S-C_8H_{17}	0	93.9	99.8	100.3	124.4	146.2	164.5	180.0	193.2	204.4	214.1
C_9H_{19}-S-S-C_9H_{19}	0	104.1	110.8	111.3	138.3	162.7	183.2	200.6	215.3	227.9	238.8
$C_{10}H_{21}$-S-S-$C_{10}H_{21}$	0	114.4	121.7	122.3	152.2	179.1	201.9	221.1	237.4	251.4	263.4

* In order to retain internal consistency, the values in this and the following tables are given to more significant figures than is warranted by the accuracy of the calculations.

Table 4

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Enthalpy Function $\frac{H°-H_o°}{T}$ cal / mole °K										
CH_3-S-S-CH_3	0	15.44	16.00	16.04	18.15	20.15	22.00	23.74	25.35	26.83	28.20
C_2H_5-S-S-C_2H_5	0	21.92	22.85	22.92	26.54	30.05	33.33	36.36	39.11	41.62	43.92
C_3H_7-S-S-C_3H_7	0	29.2	30.5	30.5	35.5	40.3	44.8	49.0	52.9	56.4	59.7
C_4H_9-S-S-C_4H_9	0	35.4	37.1	37.2	43.5	49.8	55.7	61.1	66.1	70.7	75.0
C_5H_{11}-S-S-C_5H_{11}	0	41.7	43.7	43.9	51.7	59.3	66.5	73.2	79.4	85.1	89.3
C_6H_{13}-S-S-C_6H_{13}	0	48.1	50.4	50.5	59.8	68.9	77.4	85.4	92.7	99.4	105.6
C_7H_{15}-S-S-C_7H_{15}	0	54.4	57.0	57.2	67.9	78.4	88.3	97.5	106.0	113.8	121.0
C_8H_{17}-S-S-C_8H_{17}	0	60.7	63.7	63.9	76.0	88.0	99.2	109.6	119.3	128.1	136.3
C_9H_{19}-S-S-C_9H_{19}	0	67.0	70.4	70.6	84.2	97.5	110.0	121.7	132.6	142.5	151.6
$C_{10}H_{21}$-S-S-$C_{10}H_{21}$	0	73.3	77.1	77.3	92.3	107.1	120.9	133.9	145.9	156.9	166.9

Table 5

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Free enthalpy Function $\frac{G°-H_o°}{T}$ cal / mole °K										
CH_3-S-S-CH_3	0	— 63.07	— 64.46	— 64.56	— 69.47	— 73.73	— 77.59	— 81.10	— 84.38	— 87.44	— 90.34
C_2H_5-S-S-C_2H_5	0	— 74.26	— 76.23	— 76.37	— 83.45	— 89.75	— 95.53	—100.90	—105.93	—110.69	—115.20
C_3H_7-S-S-C_3H_7	0	— 85.3	— 87.5	— 88.1	— 97.5	—105.9	—113.7	—120.9	—127.7	—134.1	—139.8
C_4H_9-S-S-C_4H_9	0	— 96.7	— 99.8	—100.0	—111.7	—122.0	—131.6	—140.6	—149.1	—157.1	—164.3
C_5H_{11} S-S-C_5H_{11}	0	—108.4	—112.0	—112.3	—126.0	—138.4	—149.8	—160.6	—170.8	—180.4	—190.2
C_6H_{13}-S-S-C_6H_{13}	0	—119.9	—124.1	—124.5	—139.3	—154.6	—168.0	—180.4	—192.4	—203.6	—214.0
C_7H_{15}-S-S-C_7H_{15}	0	—131.3	—136.2	—136.5	—153.1	—170.7	—185.9	—200.2	—213.8	—226.6	—238.6
C_8H_{17}-S-S-C_8H_{17}	0	—142.7	—148.1	—148.5	—167.6	—186.8	—203.8	—219.9	—235.2	—249.7	—263.2
C_9H_{19}-S-S-C_9H_{19}	0	—154.1	—160.0	—160.5	—181.6	—202.9	—221.8	—239.6	—256.6	—272.7	—287.8
$C_{10}H_{21}$-S-S-$C_{10}H_{21}$	0	—164.4	—171.9	—172.5	—195.8	—219.0	—239.7	—259.3	—277.9	—295.7	—312.4

Table 6

Compound	TEMPERATURE °K									
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Entropy S° $\frac{cal}{mole\ °K}$										
CH_3-S-S-CH_3	0	78.52	80.46	80.60	87.62	93.88	99.59	104.84	109.72	114.27	118.53
C_2H_5-S-S-C_2H_5	0	96.18	99.07	99.28	109.99	119.81	128.87	137.26	145.04	152.32	159.13
C_3H_7-S-S-C_3H_7	0	114.5	118.3	118.6	133.0	146.2	158.5	169.9	180.6	190.5	199.5
C_4H_9-S-S-C_4H_9	0	132.1	136.9	137.2	155.2	171.8	187.3	201.7	215.2	227.8	239.3
C_5H_{11}-S-S-C_5H_{11}	0	150.1	155.7	156.2	177.7	197.7	216.3	233.8	250.2	265.5	279.5
C_6H_{13}-S-S-C_6H_{13}	0	168.0	174.5	175.0	199.1	223.5	245.4	265.8	285.1	303.0	319.6
C_7H_{15}-S-S-C_7H_{15}	0	185.7	193.2	193.7	221.3	249.1	274.2	297.7	319.8	340.4	359.6
C_8H_{17}-S-S-C_8H_{17}	0	203.4	211.8	212.4	243.6	274.8	303.0	329.5	354.5	377.8	399.5
C_9H_{19}-S-S-C_9H_{19}	0	221.1	230.4	231.1	265.8	300.4	331.8	361.3	389.2	415.2	439.4
$C_{10}H_{21}$-S-S-$C_{10}H_{21}$	0	238.7	249.0	249.8	288.1	326.1	360.6	393.2	423.8	452.6	479.3

Table 7

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Heat of Formation $\Delta H°_f$ $\frac{kcal}{mole}$ *										
CH_3-S-S-CH_3	—32.65	— 36.32	— 36.59	— 36.61	— 37.54	— 38.28	— 38.86	— 39.26	— 39.50	— 39.62	— 39.61
C_2H_5-S-S-C_2H_5	—42.01	— 48.03	— 48.46	— 48.49	— 50.01	— 51.19	— 52.07	— 52.69	— 53.09	— 53.30	— 42.01
C_3H_7-S-S-C_3H_7	—49.99	— 58.15	— 58.72	— 58.78	— 61.0	— 62.6	— 63.8	— 64.7	— 65.3	— 65.6	— 65.6
C_4H_9-S-S-C_4H_9	—57.87	— 68.45	— 69.18	— 69.23	— 72.1	— 74.2	— 75.8	— 77.1	— 77.8	— 78.3	— 78.3
C_5H_{11}-S-S-C_5H_{11}	—65.32	— 78.29	— 79.22	— 79.31	— 82.8	— 85.4	— 87.5	— 88.9	— 89.9	— 90.4	— 90.5
C_6H_{13}-S-S-C_6H_{13}	—72.53	— 87.96	— 88.98	— 89.06	— 93.2	— 96.3	— 98.8	—100.5	—101.7	—102.4	—102.5
C_7H_{15}-S-S-C_7H_{15}	—79.80	— 97.53	— 98.84	— 98.90	—103.7	—107.3	—110.2	—112.2	—113.6	—114.3	—114.5
C_8H_{17}-S-S-C_8H_{17}	—83.44	—107.22	—108.70	—108.76	—114.2	—118.3	—121.6	—123.9	—125.5	—126.3	—126.5
C_9H_{19}-S-S-C_9H_{19}	—87.09	—116.91	—118.55	—118.63	—124.7	—129.3	—133.0	—135.6	—137.4	—133.3	—138.5
$C_{10}H_{21}$-S-S-$C_{10}H_{21}$	—90.73	—126.59	—128.41	—128.49	—135.2	—140.4	—144.4	—147.4	—149.4	—150.3	—150.5

* Reaction: 2 n C (graphite) + (2 n + 1) H_2 (g) + S_2 (g) ⟶ C_nH_{2n+1}-S-S-C_nH_{2n+1} (g).

Table 8

Compound	TEMPERATURE °K										
	0	273.15	298.15	300	400	500	600	700	800	900	1000
	Free Enthalpy of Formation $\Delta G°_f$ $\frac{kcal}{mole}$ **										
CH_3-S-S-CH_3	—32.65	—17.34	—15 60	—15.47	—8.28	—0.88	6.65	14.28	21.94	29.64	37.35
C_2H_5-S-S-C_2H_5	—42.01	—16.50	—13.60	—13.38	—1.44	10.85	23.34	35.96	48.66	61.39	74.13
C_3H_7-S-S-C_3H_7	—49.99	—14.22	—10.07	— 9.88	6.8	23.9	41.3	58.9	76.6	94.4	112.6
C_4H_9-S-S-C_4H_9	—57.87	—11.95	— 6.77	— 6.34	15.0	37.1	59.5	82.1	104.9	127.9	151.2
C_5H_{11}-S-S-C_5H_{11}	—65.32	— 9.33	— 2.96	— 2.48	23.6	50.5	77.9	105.6	133.4	161.4	189.9
C_6H_{13}-S-S-C_6H_{13}	—72.53	— 6.49	1.09	1.65	32.5	64.3	96.7	129.4	162.3	195.2	229.0
C_7H_{15}-S-S-C_7H_{15}	—79.80	— 3.66	5.12	5.77	41.4	78.1	115.4	153.3	191.3	229.5	268.2
C_8H_{17}-S-S-C_8H_{17}	—83.44	— 0.84	9.14	9.88	50.2	91.8	134.2	177.1	220.2	263.5	307.3
C_9H_{19}-S-S-C_9H_{19}	—87.09	0.98	13.16	13.89	59.1	105.6	153.0	200.9	249.1	297.5	346.5
$C_{10}H_{21}$-S-S-$C_{10}H_{21}$	—90.73	3.80	17.17	17.91	68.0	119.4	171.7	224.7	278.0	321.5	385.6

** Reaction: 2 n C (graphite) + (2 n + 1) H_2 (g) + S_2 (g) ⟶ C_nH_{2n+1}-S-S-C_nH_{2n+1} (g).

heats of formation from Table 1, we calculated the heats of formation and free enthalpies of formation of the gaseous symmetrical dithia alkanes. The values are presented in Tables 7 and 8.

With the help of the free enthalpies of formation given in Table 8 we calculated for the contribution of a –S–S– group to the enthalpy of formation (see correlation given in Part 26 of this series).

$$\Delta G_f°_{-S-S-} = -18.606 + 2.664 \cdot 10^{-2}\,T \quad (300 \ldots 600\ °K)$$

$$\Delta G_f°_{-S-S-} = -18.204 + 2.597 \cdot 10^{-2}\,T \quad (600 \ldots 1000\ °K)$$

In order to retain internal consistency with the correlation given previously[8] the constants in these formulas are presented to more significant figures than is warranted by the accuracy of the correlation.

With the help of these formulas and the correlation given before[8] the free enthalpy of the gaseous dithia alkanes, starting from 4,5 dithiaoctane, can be calculated with an average deviation of ± 0.5 $\frac{kcal}{mole}$ and a maximum deviation of ± 1 $\frac{kcal}{mole}$.

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Key Words for Indexing

Dithia alkanes
Enthalpy
Entropy
Heat capacity
Petrochemicals
Thermodynamics

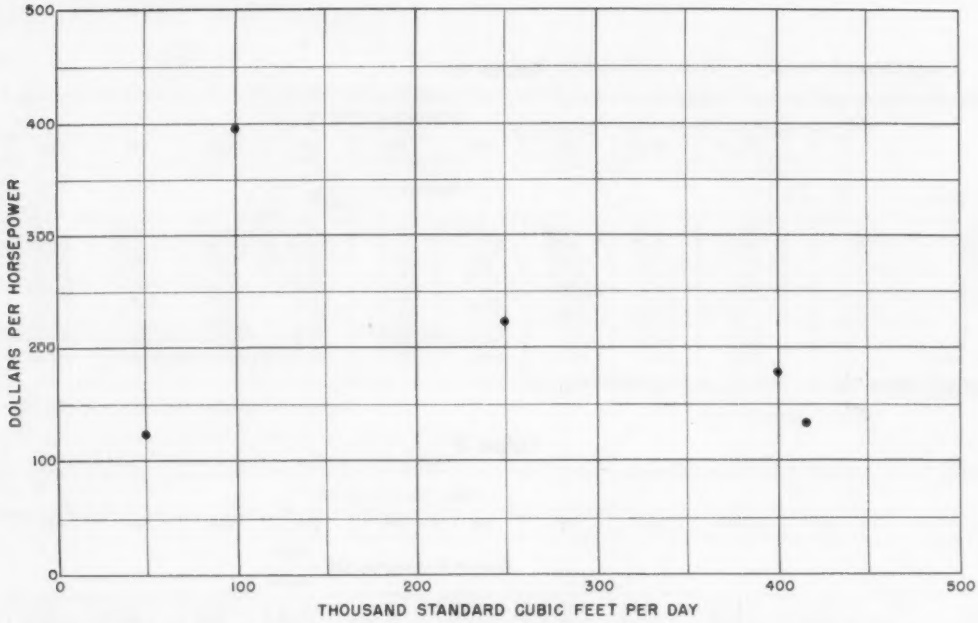

FIGURE 1—Here is how cost per horsepower varied for several Continental installations.

How Conoco Justified Vapor Recovery

Conoco has installed five lease vapor recovery systems in the Denver-Julesburg basin to conserve gas for the Little Beaver Gas Plant. Here's how they justified the $17,000 investment

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Besides vapor conservation, Continental Oil Company has realized $29,440 gross monthly income from five lease vapor recovery systems. Installed within the past year, the units are located in the Denver-Julesburg Basin fields near Fort Morgan, Colo. Equipment selection, economics and operating experiences are outlined here.

The wide acceptance and use of lease automatic custody transfer (LACT) and the strategic location of gasoline plants in the Denver-Julesburg basin have provided a supply (and a market) of large volumes of rich stock tank vapors. By installing small skid-mounted compressors to gather, compress and inject these rich vapors into the gathering system, Continental Oil Company, as operator of the Little Beaver Gas Plant, has been able to practice conservation and increase revenue to both the gasoline plant and producer.

Continental made the initial installation at the Little Beaver "D" Sand Unit LACT stock tank in October 1960. Four additional installations were made through February 1961, at the Big Beaver, Plum Bush Creek Unit, Little Beaver East Unit and Kejr Unit batteries.

The installations process from 43 MSCFPD to 640 MSCFPD with oil production at the batteries ranging from 1200 BOPD to 9100 BOPD.

Three different makes of compressor units are in operation. In general, the selection of equipment has been based on installed cost, delivery time and a desire to gain operating experience with different makes of compressors.

The criteria upon which the evaluations are made for a vapor recover installation include the following:

TABLE 1

Area	Type Installed	Production B/d	CAPACITY MSCFPD		PRESSURES PSIG		Gas Gravity	Hp.	Installed Cost, $	$/Hp.
			Design	Actual	Suction	Discharge				
LBDSU	Sliding Vane..... Direct Drive	2,000	100	88	4 oz.	8	1.900	5	1,975	395
Big Beaver	Sliding Vane..... Direct Drive	1,900	415	415	15	39	1.335	30	3,980	133
PBCU	Sliding Vane..... Belt Drive	9,100	250 400	210 430	4 oz. 4 oz.	24 24	1.710 1.365	20 30	4,450 5,300	222 177
LBEU	Double Impeller.... Belt Drive	1,200	50	43	4 oz.	7	1.840	5	620	124
KEJR Unit	Double Impeller.... Belt Drive	1,200	50	48	4 oz.	7	1.775	5	620	124

1. Measurement of the volume of stock tank vapor available on the lease with an orifice meter.
2. A compression test to determine the gross gallons per 1,000 cubic foot liquid recovery on the lease.
3. An economic study based on the casinghead gas concontract for the respective lease and the estimated cost of the vapor recovery installation.

Equipment Selected. All five installations made by Continental Oil Company in the Denver-Julesburg basin have high speed (over 600 rpm) positive displacement, single stage, rotary compressors driven by electric motors. The three different makes include two sliding vane types and one double impeller type. Two of the makes feature a belt drive and the other is directly coupled to the motor. One type compressor is equipped with a suction scrubber. A second type includes a jacket water cooler and radiator.

All installations are equipped with bourdon tube type pressure shutdown controls and/or automatic bypasses to prevent pulling a vacuum on any vessel.

All fields in which vapor recovery equipment is installed are electrified, and electric motor prime movers are used for the compressors. Electric motors are also preferable because residue gas is not available in all cases. The use of rich lease gas as a fuel is not economically attractive and it creates additional operating problems during cold weather.

Present Installations. Table 1 describes the equipment, operating conditions and costs of the installations made by the Continental Oil Company's Little Beaver Gas Plant.

Figure 1 is a graphic illustration of installed dollars/horsepower versus capacity. It can be seen that costs have varied widely; however, cost was not necessarily the determining factor in Continental's installations, since it was advantageous to gain operating experience with the three different makes of units to aid in future operations. The availability of the equipment also was considered in the installations. The loss in revenue due to delivery time could be substantial as may be seen in the following payout data.

Payout Data. A sample payout formula and calculations of the payout for the gas plant and income to the primary oil producer are shown in Tables 2, 3, 4 and 5. For purposes of these sample calculations, it was assumed that 25 percent of the liquids and 50 percent of the residue gas were credited back to the producing lease. This assumption conforms closely with actual figures for the Little Beaver Gas Plant. Prices used for residue gas and liquid products were taken from actual 1960 figures at the Little Beaver Plant. The shrink of 35 percent is also realistic for this plant.

The gas plant installed the vapor recovery equipment in these five fields. So the primary oil producer in these cases receives from $390 to $3,795 per month with no additional investment. It is therefore to the economic advantage of both the producer and gas plant to investigate every producing lease for possible vapor recovery applications.

Installation, Operation and Maintenance. Continental's experience with vapor recovery units after ten months operation in the Denver-Julesburg Basin is applicable to any similar installations in the Rocky Mountain area.

All units are skid-mounted and have been placed on concrete foundations four inches thick. The foundation is mainly to provide a level surface and for hold down, although very little vibration has occurred.

TABLE 2

Plant Income:
Liquids
Gross Gas X GPM X Liquids (.75) X Liquid Price Per Gallon.
Residue Gas
Gross Gas X Residue Gas (.50) X Net After Shrink (.65) X Price Per MCF.
Producers' Income:
Liquids
Gross Gas X GPM X Liquids Returned (.25) X Net Interest (.875) X Liquids Price Per Gallon.
Residue Gas
Gross Gas X Residue Gas Returned (.50) X Net Interest (.875) X Net After Shrink (.65) X Price Per MCF.

TABLE 3—Little Beaver "D" Sand Unit Plant Data

Costs:	
Investment	$1,525
Installation	450
Operating Expense per month	30
Total	$2,005
Income:	
Gas Volume—LACT	88 MSCFD
Test Content	25.0 gpm
Average Price—LPG	4.5¢/gal.
Residue Gas	16.0¢/MSCF
Gross Income—LPG	$2,250/mo.
Gross Income—Residue Gas	140/mo.
Total Income	$2,390/mo.
Payout Period Before Taxes and Depreciation	0.8 mos.

PRODUCER DATA

Costs:	$ 0
Income (after royalty):	
Gas Volume	88 MSCFD
Test Content	25.0 gpm
Average Price—LPG	4.5¢/gal.
Residue Gas	14.0¢/MCF
Gross Income—LPG	$ 660/mo.
Gross Income—Residue Gas	105/mo.
Total Income	$ 765/mo.

TABLE 4—PBCU Field Plant Data

Costs:	
Investment	$ 8,750
Installation	1,020
Operating Expense per month	230
Total Income	$10,000
Income:	
Gas Volume—LACT	210 MCFPD
Gas Volume—Treater	430 MCFPD
Test Content—LACT Vapors	27.8 gpm
Test Content—Treater Vapors	9.9 gpm
Average Price—LPG	4.5¢/gal.
Residue Gas	16.0¢/MCF
Gross Income—LPG	$10,355/mo.
Gross Income—Residue Gas	1,010/mo.
Total Income	$11,365/mo.
Payout Period—Before Taxes and Depreciation	0.9 mos.
PRODUCER DATA	
Costs:	$0
Income (after royalty):	
Gas Volume—LACT	210 MCFD
Gas Volume—Treater	430 MCFD
Test Content—LACT Vapors	27.8 gpm
Test Content—Treater Vapors	9.9 gpm
Average Price—Total LPG	4.5¢/gal.
Residue Gas	14¢/MCF
Gross Income—LPG	$ 3,020/mo.
Gross Income—Residue Gas	775/mo.
Total Income	$ 3,795/mo.

TABLE 5—Little Beaver East Unit Plant Data

Costs:	
Investment	$ 470
Installation	150
Operating expense per month	30
Total	$ 650
INCOME:	
Gas Volume—LACT	43 MCFD
Test Content	26.5 gpm
Average Price—LPG	4.5¢/gal.
Residue Gas	16.0¢/mcf
Gross Income—LPG	$1,170/mo.
Gross Income—Residue Gas	70/mo.
Total Income	$1,240/mo.
Payout Period Before Taxes and Depreciation	0.5 mos.
PRODUCER DATA	
Costs:	$0
Income (after royalty):	
Gas Volume—LACT	43 MCFD
Test Content—LACT	26.5 gpm
Average Price—LPG	4.5¢/gal.
Residue Gas	14.0¢/MCF
Gross Income—LPG	$ 340/mo.
Gross Income—Residue Gas	50/mo.
Total Income	$ 390/mo.

If it is anticipated that liquid could enter the compressor, inlet scrubbers should be installed with automatic dumps. It has been found that insulation of the scrubber and dump valve is necessary to prevent freezing. Mist or minute drops of liquid have not affected the compressors, but liquid slugs will damage the vanes or impellers.

Extreme care should be taken to insure that no air enters the system through thief hatches on the stock tanks. This can be accomplished by mounting a pressure control switch directly on the tank or by providing a bypass to maintain a predetermined inlet pressure. The automatic bypass is especially applicable for multiple stock tanks manifolded together.

One of the direct drive compressors failed because of misalignment when the unit was fabricated. The belt drive units offer more flexibility than the direct drive units because the speed can be adjusted to meet present load conditions, and alignment is not critical. It has been necessary to flush the steel vaned compressors once a month with kerosine to remove sludge and prevent sticking. However, all vane type compressors are cleaned at regular intervals to insure freedom of movement of the vanes.

The oil consumption on the vane type compressors has averaged a quart per 24 hours.

The compressors equipped with timing gears immersed in an oil bath have a bearing seal between the impellers and gears. Some gas leakage has occurred through the bearing seal and contaminated the oil bath. This has resulted in two bearing failures and one timing gear failure. These failures in turn caused extreme impeller and housing wear.

The fiber bakelite vane compressor appears to be the most efficient at the present time, possibly due to a better seating surface to the rotor housing.

Selection of the proper safety controls and a good preventive maintenance program are vital for successful and trouble-free operations.

The attractive economics and successful operations of these units has initiated a complete survey of Continental's entire producing operations in the Rocky Mountain area for possible additional installations.

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Key Words for Indexing

Compressors
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Recovering
Stocks
Tanks
Vapor Phase

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Microscope Speeds Diagnosis of Refinery Corrosion

Case histories show invaluable use of microscope in identifying the mode and manner of corrosion attack on refinery equipment

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Everyone connected with oil refining technology is aware of the destruction of property caused principally by corrosion. Besides the usual loss of production, there is in addition a psychological fear of possible explosive failure of the equipment. Thus, practically everyone in the oil refining business is corrosion minded.

In combating this corrsion in an oil refinery, one finds, in addition to ordinary wasting of metals, many different types of corrosion. To differentiate these special corrosion problems, the aid of the microscopic analysis has been found invaluable. To illustrate how metallographic diagnosis helps to clarify and identify failures caused by corrosion, a few classified examples will be described. It will be shown that very often failure is caused by a combination of factors including the types, quality, and condition of the metal or alloy, and to the service environment, rather than to any one specific factor.

Pitting Corrosion. Instead of a uniform thinning in a corrosive environment, a metal very often suffers localized attack resulting in pitting. Figure 1 illustrates such pitting in a vertical, straight section of a ½-inch tube which handled gas from the regenerator of a Fluid Catalytic Cracking Unit. The products of corrosion were principally iron hydroxides with some iron sulfates.

Stainless steels, which resist many corrosive media, in some solutions when they do corrode, are particularly subject to pitting. This is true of all metallic materials which owe their corrosion resistance to their ability of building up a surface passivity under certain environments. This is also true of chromium, nickel, aluminum, and their alloys. Figure 2 illustrates pitting of a stainless-steel tube on the

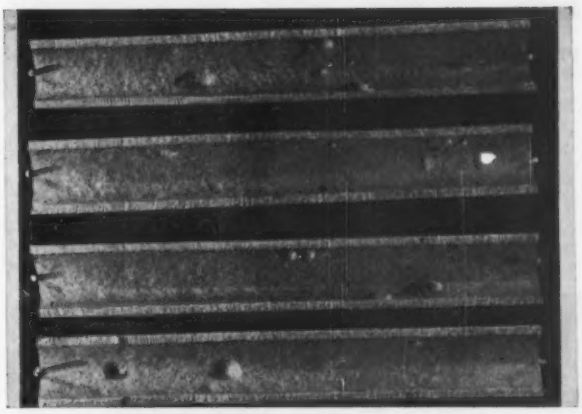


FIGURE 1—Straight section of one-half-inch steel tubing failed by pitting corrosion.

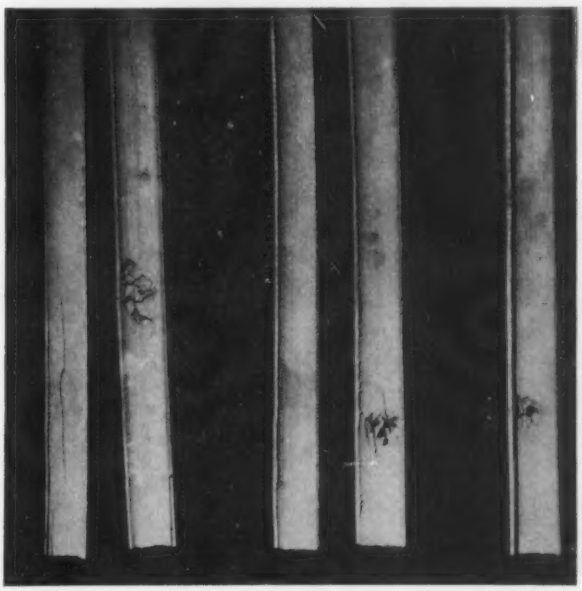


FIGURE 2—Pitting of 18-8 on water side of shell and tube condenser.

water side from a shell and tube type condenser. It is significant to note how small an area of inside surface these failures cover. The tube may have a pit that would actually perforate the tube then be perfect for a foot or two. Modern theory of pitting presupposes a formation of a pit at a minute area of a metal surface which suffers a breakdown in passivity. This breakdown is followed by the formation of an electrolytic cell the anode of which is a minute active area at the pit and the cathode of which is a large passive surface area surrounding the pit. This behavior favors the tendency of corrosion to penetrate the metal at the pit rather than to spread along the entire surface.

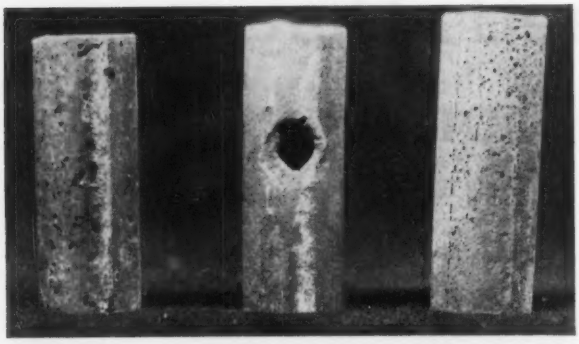


FIGURE 3—Pitting caused by acid derivatives of naphtha.

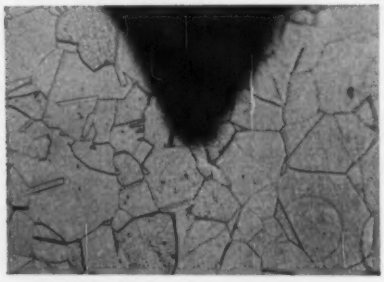


FIGURE 4—Section through pit at bottom. Austenitic structure. X250

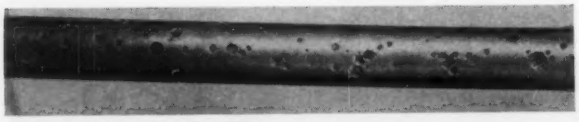


FIGURE 5—Dezincification of admiralty tube in crude pipe still.

Pitting may also result from the attack by the acid derivatives of naphtha. Such a condition is shown in Figure 3. A section through one of the pits illustrating the normal structure is shown in Figure 4.

A localized attack on an admiralty (nominal composition copper 70 percent, zinc 29 percent, tin 1 percent) exchanger tube is shown in Figure 5. This is caused by a special type of corrosion designated as dezincification. As the name implies, zinc is corroded out, leaving as a residue a porous mass of copper. Presently, it is thought that the metal is dissolved as a whole, and the copper is reprecipitated as the end result of corrosion. Alloys with higher copper content are less likely to suffer this type of attack.

Intergranular Corrosion. When metallic alloys under the microscope show a homogeneous solid solution, they may resist corrosion equally well as either of the parent metals. However, when they show more than one phase, they may be subject to a localized attack.

Failures of 18 percent chromium, 8 percent nickel stainless steel are often a result of structural changes in the metal itself. These may be a result of heating during fabrication or due to the temperature of the service. When the above steel is heated in the range of 1000-1400° F, chromium carbides precipitate along the grain boundaries, thus forming the second phase. The percentage of chromium in precipitated carbides is several times that of the original alloy; thus, they improverish the metal films along the grain boundaries, lessening the resistance of the metal to the corrosive attack. This change is illustrated in Figures 6 and 7.

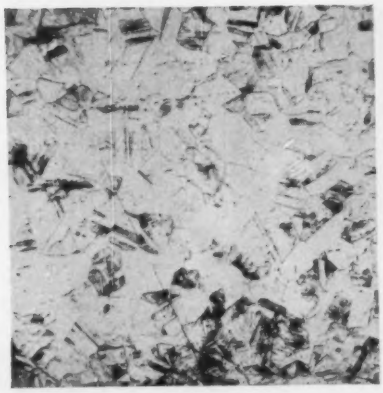


FIGURE 6—18-8 steel as received showing normal structure. X100

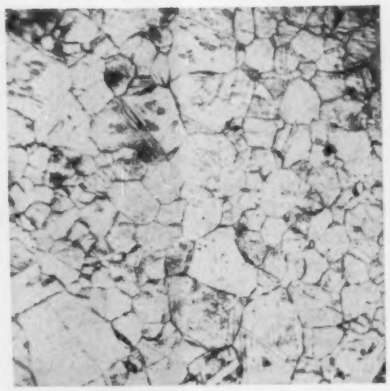


FIGURE 7—Same steel as Figure 6 after heating to 1240° F for 1510 hours. X100

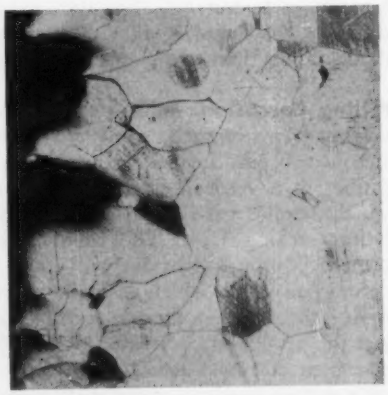


FIGURE 8—Intergranular corrosion of tube in low temperature service. X100

The following examples of failures illustrate what happens when metal containing such a structure is subjected to a corrosive environment:

Low temperatures. Exchanger tubes made by fusion welding an 18-8 strip failed by outside pitting. Because of the heating of the metal in the welding operation, the carbide precipitation occurred. (Analysis of the tubes: carbon .06 percent, chromium 17.87 percent, nickel 7.58 percent.) The resulting corrosion was intergranular. The failure of these tubes is illustrated in Figure 8.

High temperature. Figure 9 illustrates failures in four cases of 18-chromium, 8-nickel tubes. These tubes, 4½-inch OD by 0.4-inch wall thickness, were used in the radiant section of a cracking unit heater; thus, they were subject to the sensitive temperature of chromium carbide precipitation. The cracks, resulting from corrosive gases attacking the metal, were intergranular in character. The etched section of one of the tubes is shown in Figure 10. The failure is further illustrated in Figure 11 by showing carbide precipitation in the metal as a result of exposure to the operating temperature of the heater. The intergranular cracks starting from the outside surface are shown in Figure 12.

Another example of intergranular cracking occurred in an oil still float. The failure is shown in Figure 13. The float was made by deep drawing sheets into semispheres which were subsequently welded. The heat of the welding precipitated the carbides in a zone adjacent to the weld, thus making the steel susceptible to intergranular corrosion. This is shown in Figure 14.

Cavitation Corrosion. Cavitation is defined as a damage to a material associated with the formation and collapse of cavities within the fluid. The damage is principally caused by mechanical action. This has been demonstrated by the roughening of a surface of polished glass as a result of experimental cavitation. A corrosive environment can, however, accelerate damage to a metal by cavitation.

Figure 15 illustrates a turbine diffusing ring which suffered damage from cavitation. It is to be noted that the damaged areas, which are preferentially located, have somewhat the appearance of the pitting type of corrosion. Microscopic examination of a specimen cut through the damaged portion of the vane showed that erosion caused the principal amount of damage. Figures 16 and 17, however, show that corrosion has also taken place at the bottom of a large pit. The remedy for this damage can be alleviated (1) by admitting air to the flowing liquid and (2) by repairing damaged areas by facing them with the 18-8 stainless steel.

Corrosion Involving Stressed Materials. Whenever the combined effects of corrosion and stresses are considered, they are usually divided into two classes:

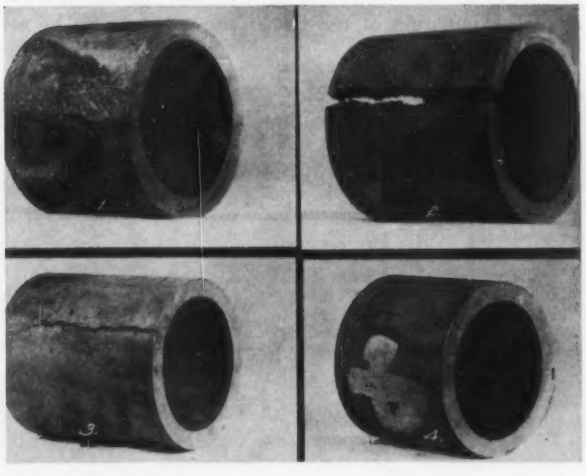


FIGURE 9—Intergranular cracks of 18-8 furnace tubes. There is an apparent lack of swelling, scaling, or thinning.

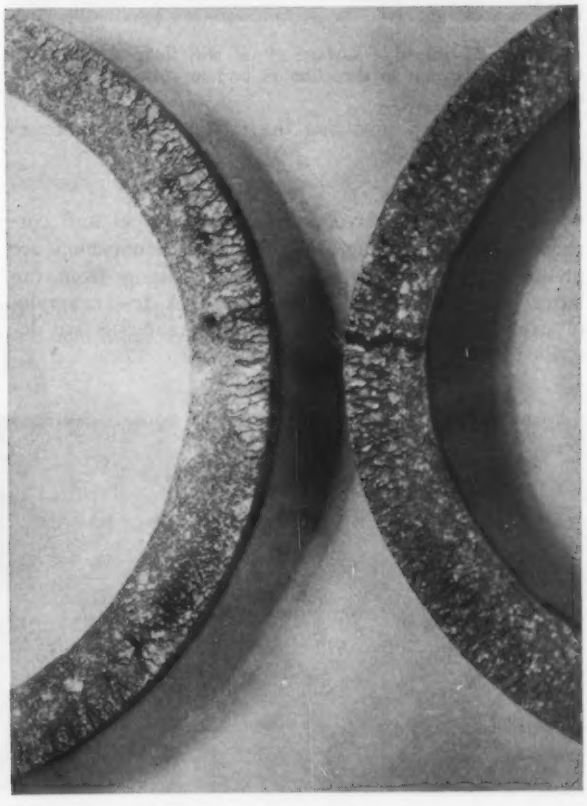


FIGURE 10—Etched transverse section of one Figure 9 tube showing outside radial cracks.

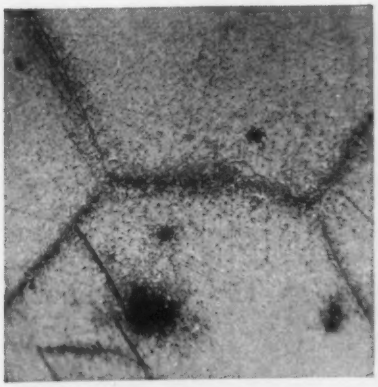


FIGURE 11—Carbide precipitated along the grain boundaries. X1000

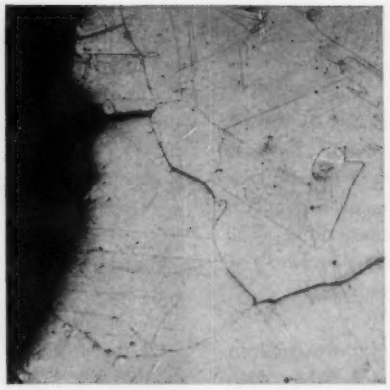


FIGURE 12—The intergranular crack starts at the outside of the tube. X100

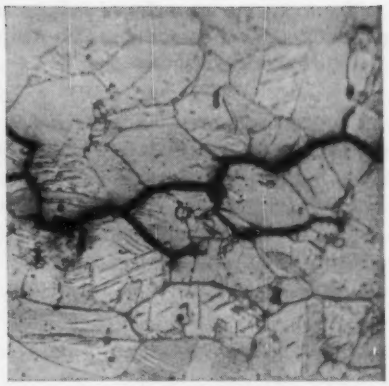


FIGURE 14—Section through cracked float shows intergranular cracking. X500

FIGURE 13—Outside surface of oil still float at the weld. Cracks are normal in direction to and in close proximity of the Weld.

• Stress corrosion involving the effects of static stresses and corrosion.

• Corrosion fatigue involving variable stresses and corrosion. Cracks resulting from the first phenomenon are predominantly intergranular; those resulting from the latter phenomenon are transgranular. A few examples of stress corrosion failures of different materials are described in the following paragraphs.

STRESS CORROSION

Brass. Stress corrosion as a problem was first recognized in encountering the cracking of brass, particularly cartridge brass. The cracks were predominantly intergranular. In refinery service, however, intergranular cracks, shown in Figure 18 are rare. Most of the cracking is transgranular. Ammonia, for example, which is being used as one of the principal corrosive agents in accelerating stress corrosion tests, produces transgranular cracks

FIGURE 19—Circumferential and radial cracking of brass condenser tube.

in actual service. Figure 19 shows both circumferential and radial cracking in admiralty tubing. Circumferential cracking occurred in service and longitudinal cracks were produced by the slight tapping with a hammer. Microscopic examination of the cracks showed these to be of

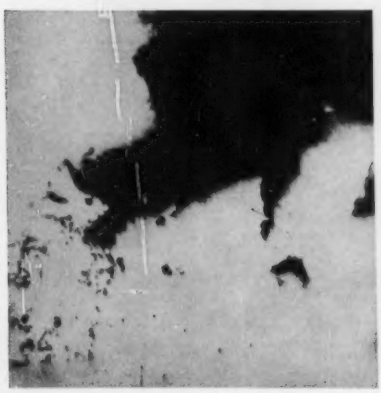


FIGURE 16—Section through ring showing corrosion at bottom of pits. X100

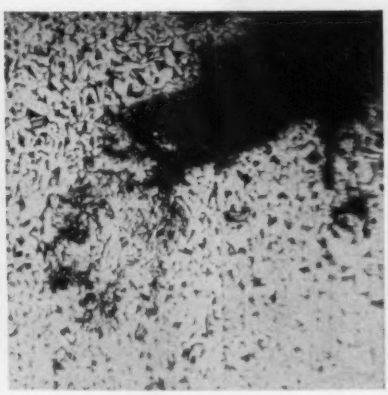


FIGURE 17—Same field as Figure 16. Etch picric acid in alcohol. X100

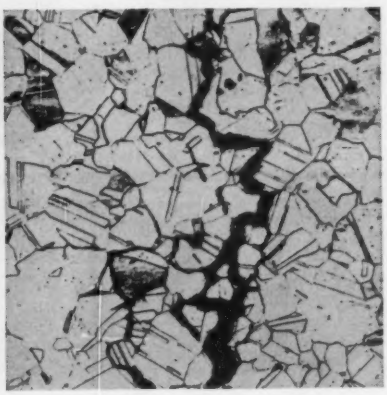


FIGURE 18—Intergranular cracking in brass tube typical of stress corrosion.

FIGURE 15—Turbine diffusion ring damaged by cavitation.

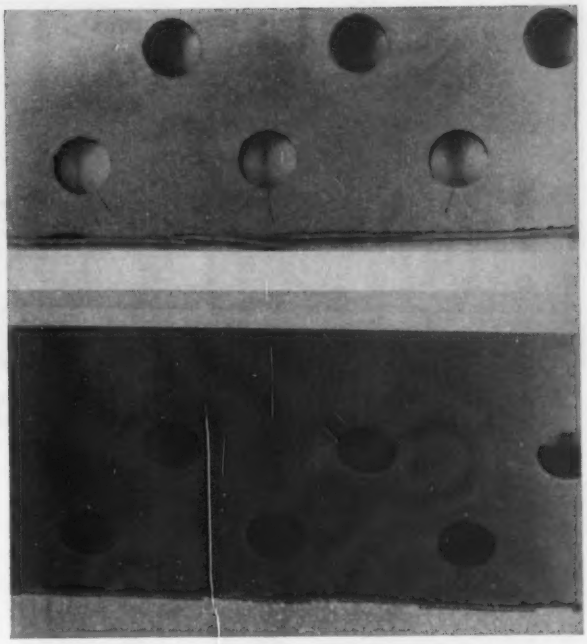
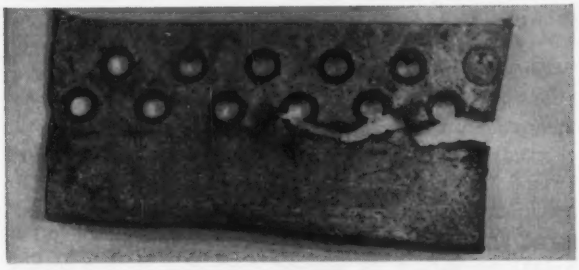


FIGURE 22 (above)—Cracks arising from stressed metal at the rivet holes. Evidently, the rivet holes were punched out of the plate and then not stress-relieved.



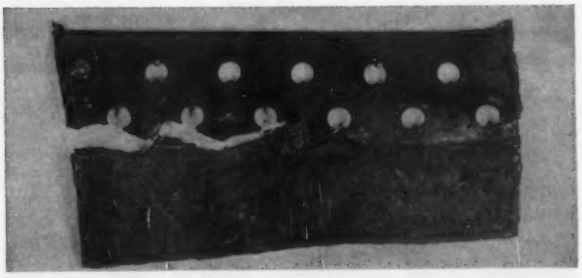


FIGURE 21 (left)—Fractured plates from mud drum of riveted boiler.

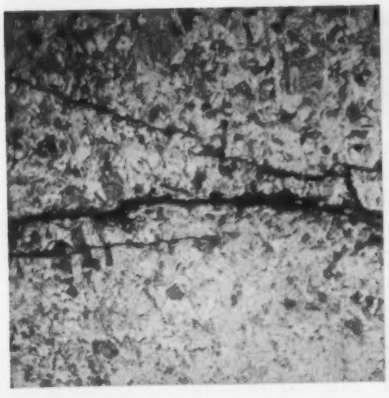


FIGURE 20—Transgranular cracking of brass tube by ammonia. X100

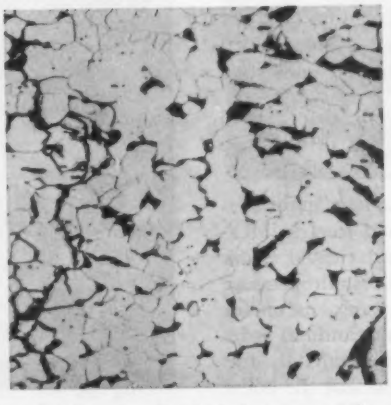


FIGURE 23—Typical intergranular cracks in rivet holes. X250

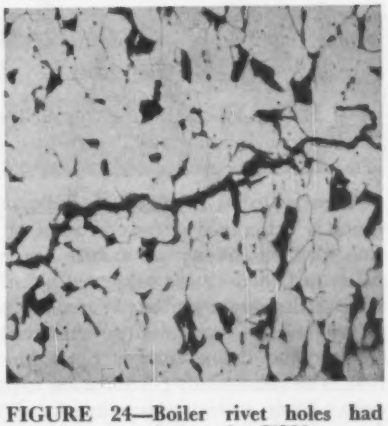


FIGURE 24—Boiler rivet holes had these intergranular cracks. X250

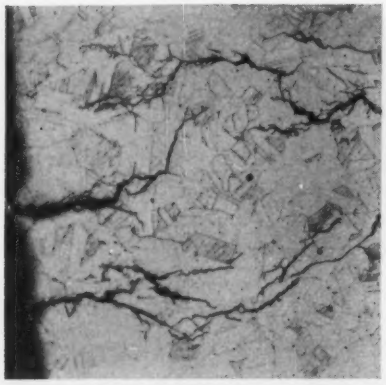


FIGURE 26—Transgranular cracking of 18-8 moly. tube in chloride solution. X150

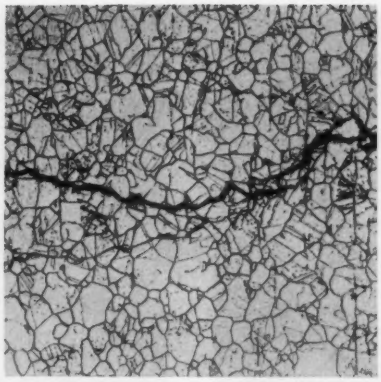


FIGURE 27—Transgranular cracking of 18-8 condenser shell by chlorides. X150

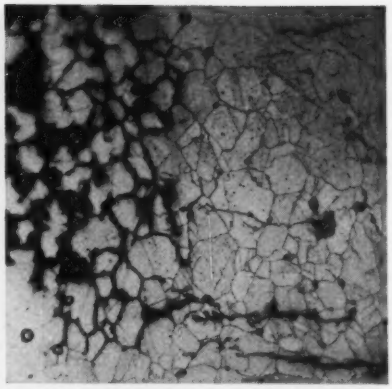


FIGURE 29—Intergranular surface cracks and transgranular center cracks. X250

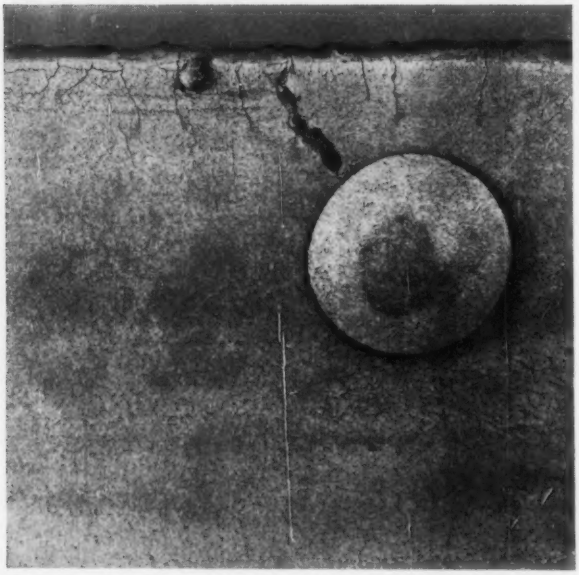


FIGURE 25—Riveted tank in caustic service. Cracks originated from caulked edge of the plate and from rivet holes.

transgranular nature. Refer to Figure 20. This exchanger was used for cooling vapors from the distillation of crude benzol. The failure was due to corrosion cracking caused by ammonia in the crude benzol.

Mild Steel. The following instances of cracking of mild steel, when under residual stress, as a result of corrosive attack are now described.

Caustic Embrittlement of Boilers. Caustic embrittlement is actually a stress corrosion of mild steel in alkaline solutions. A typical failure of an old riveted boiler occurred when it was subjected to a hydrostatic pressure during the down period. When the pressure was on for approximately five minutes, the front longitudinal seam in the mud drum cracked open for approximately five feet. The subsequent examination revealed that the boiler failed from embrittlement cracks. Figure 21 shows the fractured plate from the above boiler. Another view, Figure 22, shows cracks arising from metal at the rivet holes. Typical intergranular cracks under the microscope are shown in Figures 23 and 24.

Caustic Cracking of Mild Steel. To show cracking of mild steel in alkaline solutions, besides boiler embrittlement, one other example is shown. Figure 25 shows the cracked plate from a riveted tank, which was in caustic service. The cracks were intergranular. The tank plate specimens, when tested in both longitudinal and transverse directions, had tensile strengths of from 62,500 to 63,000 psi with a 39 percent elongation in two inches. Both longitudinal and transverse specimens were bent 180 degrees upon themselves with no cracking on the outside surface. These tests are mentioned to illustrate

FIGURE 28—Cracking of bubble caps in caustic regenerator service.

that the common term of caustic embrittlement is misleading. The metal outside of the strained areas is not affected by the caustic. The steel is not actually brittle; but in strained areas where cracks originate, the caustic causes the steel to break in an apparently brittle manner.

Stainless Steel. Principal corrosive agents causing stress corrosion of stainless steels in oil refineries are mainly chlorides and also secondarily caustic. A few examples of such failures follow:

Chloride Cracking. Condensers handling naphtha at 215° F coming off the fractionating towers of one of the crude pipe stills suffered stress corrosion failures. The 18-8 moly stainless-steel tubes failed after 13 months service from transgranular cracking. A section of the tubing illustrating the nature of this type of cracking is shown in Figure 26. The tubes were used in the "as received" condition from the mill where they were heat treated by heatnig to 2000° F and water quenched.

The shell in another exchanger in exactly parallel service was made of 18-8 stainless-steel plate, AISI Type 304. The plates for this condenser were rolled cold to the proper periphery. They were then stress relieved by heating to 1600° F and furnace cooled. The shell was subsequently welded, but it was not stress relieved after welding.

It was realized that conventional treating by heating the 18-8 stainless steel to 2000° F and rapidly cooling the metal would produce a homogeneous one-phase structure, which would be the best for general corrosion resistance. However, even with this structure the metal is subject to stress corrosion cracking. Stress relief at 1600° F and slow cooling were resorted to in order to relieve the residual stresses caused by quenching. While it was realized that carbide precipitation would be developed by this treatment, it was thought that because of the agglomeration of carbides, the damage due to dual structure would be minimized.

Actually, after a short service of 4½ months, the condenser was taken out of service because of oil leakage through the shell. In spite of the carbide precipitation at the grain boundaries, the cracks were again of a transgranular nature and are illustrated in Figure 27.

Caustic Environment. The cracking of 18-8 stainless steel bubble caps in the caustic regenerator of an alkylation unit is shown in Figure 28. Cracks under a microscope of a section of a cap are shown in Figure 29. The latter photograph is particularly interesting, because it illustrates intergranular cracking at the surface and transgranular cracking at the center of the specimen. The stress in this case was residual caused by the method of fabrication, the caps being formed by cold drawing. They were not annealed after drawing as indicated by the hardness of the material which had a hardness of 135 Brinell in places not subject to drawing and 190 Brinell in places where cold drawing was severe.

CORROSION FATIGUE

Structural Steels. An interesting case of corrosion fatigue failure occurred in plungers from hot oil pumps, where the main stresses were thermal. The plungers in these pumps were hollow and were cooled with circulating water. It is readily seen that in operation when the external surface of the plungers operate at 800° F and the inside surface is cooled by water at atmospheric temperature, the metal at the inside surface is subjected to tensile stresses. If the difference of temperature is brought about suddenly rather than gradually, as happens when the water supply is interrupted for awhile, the plunger may be subjected to dynamic stresses. This severe condition of

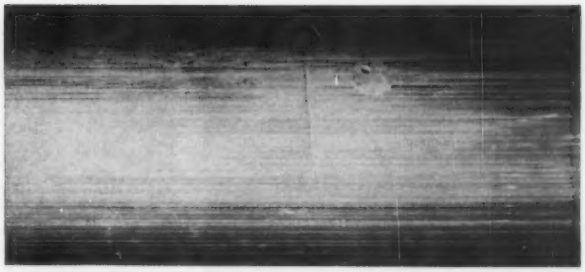


FIGURE 30—Circumferential cracks reaching outside surface of hot oil plunger. Cracks resulted from thermal stresses and corrosion.

FIGURE 31—Section through plunger wall shows pitting of inside surfaces and fatigue cracks originating from thermal stresses.

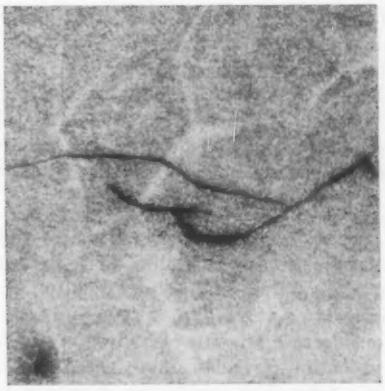


FIGURE 32—Transcrystalline nature of typical corrosion fatigue. X500

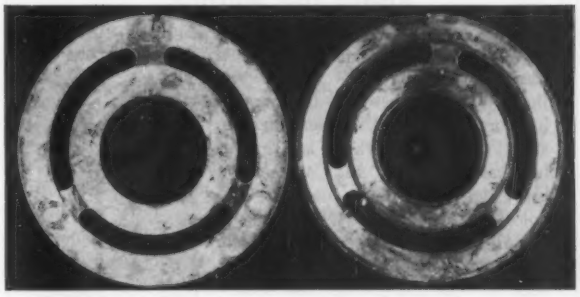


FIGURE 33—Fractured gas compressor valve discs.

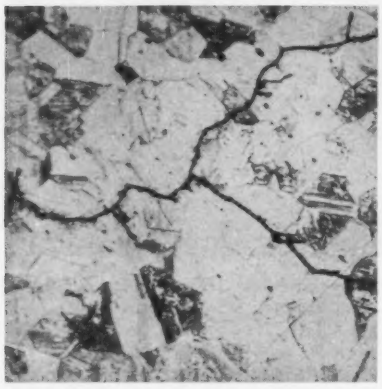


FIGURE 34—Transgranular character of typical corrosion fatigue cracking. X250

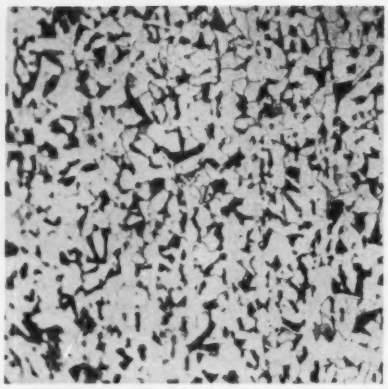


FIGURE 35—Piping section not affected by hydrogen attack. X150

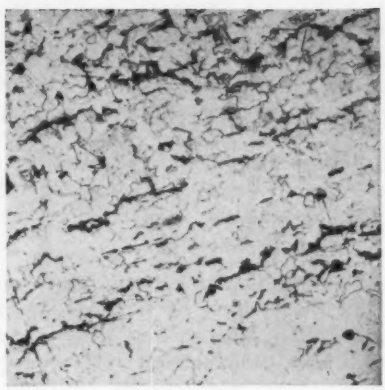


FIGURE 36—Decarburization and cracking resulting from hydrogen attack. X150

service is further aggravated by the corrosion of the inside surface caused by the circulating water. This causes pits, which in turn act as notches concentrating the stress and serving as starting points for the origin of cracks. Figure 30 illustrates a typical crack that started on the inside wall and actually penetrated to the outside. A longitudinal section through the wall of the plungers, shown in Figure 31, illustrates many parallel cracks originating on the inside surface. It also shows the pitted condition of the surface caused by corrosion. Figure 32 illustrates the transcrystalline nature of the crack, typical of corrosion fatigue.

Stainless Steel. Corrosion fatigue causes the stainless steel to crack in the same manner as in stress corrosion, when seen under the microscope. Figure 33 shows a cracked compressor valve disc. The compressed gas contained a considerable amount of hydrogen sulfide. Microscopic examination revealed these cracks to be of the transgranular type. The cracks are shown in Figure 34.

About the Author

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Wilten

HYDROGEN ATTACK

At room temperatures, hydrogen can be handled in steel cylinders even at high pressure. At elevated temperatures, however, hydrogen will attack steel. It will react with iron carbide to form methane which cannot diffuse out of the steel and, as it accumulates, creates high stresses that ultimately crack the steel.

The reaction of hydrogen with carbides in steel can be prevented by adding any of the carbide-stabilizing elements, such as, chromium, titanium, vanadium, etc. All of the austenitic stainless steels resist high temperature hydrogen damage because of their high chromium content.

Damage produced by the exposure of steels to high pressure and high temperature hydrogen is described as decarburization accompanied by intergranular cracking. (Note that nascent hydrogen, resulting from corrosion, attacks the steel in a transgranular manner.) A completely decarburized and cracked piece of carbon steel may have only 25,000 psi strength with no ductility compared with about 60,000 psi strength and 30 percent elongation in normal steel. Structures of inside and outside section of the piping which suffered hydrogen attack at elevated temperature are shown in Figures 35 and 36.

From the few examples of cited failures, one can readily see the important role that a microscopic examination may play in identifying the mode and manner of the corrosion attack.

A word of caution. The evidence obtained under the microscope must be very carefully evaluated. In mild steel, for example, the difference between stress corrosion and corrosion fatigue is clear cut; in stainless steel it is not.

Key Words for Indexing

Cavitation
Corrosion
Cracking
Chloride
Embrittlement
Fatigue
Hydrogen Attack
Intergranular
Metallography
Pitting
Stress Corrosion

For Ethylene Oxide it's . . .

Uphill for the Second Billion

Process improvements and aggressive development of new markets point to steady growth for ethylene oxide on its way to two billion pounds per year

Joseph Gordon, Los Angeles

As one of the few petrochemicals in the billion lbs./-year bracket, ethylene oxide (EO) owes its lofty position largely to the demand for ethylene glycol in automotive antifreeze. Some 60-65 percent of the EO output has been going into glycol, of which 75-80 percent goes to this single automotive use.

Since its introduction for antifreeze in 1929, this ethylene glycol outlet has also developed into a billion lbs./-year market, with an annual retail volume of $300 million. In this time glycol has captured 91 percent of the total antifreeze volume, mostly at the expense of methanol, a more volatile product. But future signs indicate a slower rate of increase in this dominant market, and therefore a smaller percentage of EO into glycol for this purpose.

Major changes are underway both in automotive markets and in automotive engine design. How these affect needs for glycol will be determined by the extent and timing of such changes. But it is already clear that they could affect the demand in many ways, some of which are bound to be unfavorable. Little encouragement could be found for example in such trends as long-lasting antifreeze, introduced in the spring of 1960. Compact cars with smaller radiator capacities took 22 percent of the new car market last year, and their share is likely to increase further.[1]

Some new types of automotive engines due for commercial appearance between 1965-1970 will not require liquid cooling. However, some high-performance engines are more likely to need glycol year-round, because of its higher efficiency as a coolant, as well as for antifreeze protection.

These coming changes in automotive use are expected to be sufficiently gradual to permit development of new or expanded applications in other areas. In this transition, producers will aim for more fully developing uses for versatile EO, the precursor for 90 percent of U.S. ethylene glycol supply.*

For EO, the two uses which are both well-established and also growing well, are the nonionic surfactants and the ethanolamines. Newer uses due to take a larger part include:

- Industrial uses such as petroleum recovery operations
- Direct use as a fumigant, and as a monopropellant
- Cellulose modification to hydroxyethylcellulose
- EO polymers and copolymers

The diesters and polyglycols are finding growing uses in synthetic lubricants, hydraulic fluids and heat transfer media. However, the leading growth sector for ethylene glycol is in polyesters, especially the glycol-terephthalates in fibers and films.

PRODUCERS EXPAND WARILY

With the evident advantages of more diversification, the results of these product developments may well prove salutary. But the unsettled current state of the antifreeze market tends to restrain further expansion either in EO or in ethylene glycol. Moreover, total U.S. capacity for EO is now some 1.6 billion pounds annually, which is ample for the foreseeable increase in demand for several years.

At the present time only two new EO units are under construction: Sun-Olin's 55 million pounds per year at Claymont, Del.; and Houston Chemical's 80 million pounds per year at Beaumont, Texas. Most of this new output is intended for ethylene glycol and each will use a different EO oxidation process.

Olin, a partner in the first venture, has been making EO from ethylene chlorohydrin since 1951. This time it will use the Shell Chemical oxygen oxidation process. Houston Chemical, newly-formed subsidiary of Chatham Reading, will operate the Scientific Design air oxidation process.

Viewed against the expansion pace of recent years, the current one seems comparatively minor. For instance, in 1957 and 1958, five companies—two of them newcomers —boosted capacity 300 million pounds. In the decade from 1949-59, total annual U.S. capacity more than tripled from 450 million to 1,500 million pounds annually. Ex-

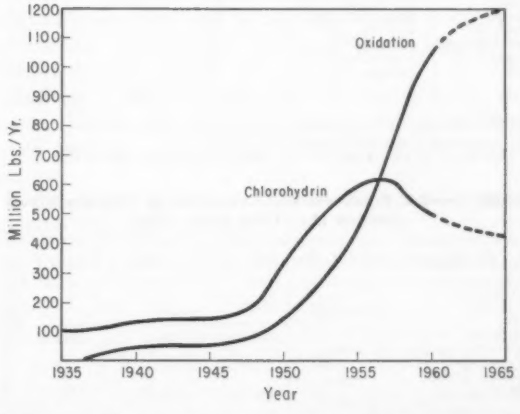

FIGURE 1—Notice the rapid decline in U.S. chlorohydrin-ethylene oxide capacity about 1957 where direct oxidation became the dominant process.

* Balance via glycolic acid

cepting the relatively recent boom in nonionics, the lion's share of this EO growth stemmed from the expanding market for antifreeze.

PROGRESS IN PROCESS

Ethylene glycol has stabilized from a low of 13½ cents in 1954[2] and one cause has been the marked shift in processing from chlorohydrin toward oxidation. Of the seven U.S. expansions in EO since 1957, only one has been via chlorohydrin. This exception was the Plaquemine, La. plant of Dow Chemical, with captive chlorine capacity. The other EO expansions have all been by oxidation processes—three using the Shell Chemical process and three using the Scientific Design process.

Chlorohydrin processing, the principal source of EO less than 10 years ago, has steadily declined in importance. Its share of the total in 1949 was ⅔; in 1960 it was ⅓ and by 1965 will probably be less than 25 percent. Some of the existing chlorohydrin capacity has been converted to propylene chlorohydrin for propylene oxide. This was done by Wyandotte, Jefferson Chemical and Union Carbide. This changing trend is shown in Figure 1.

Three reasons explain the rise of oxidation over chlorohydrin:

1. Higher chlorine cost, a rise of 25-30 percent in the past 10 years. (Two pounds of chlorine are required per pound of EO in the chlorohydrin process.)
2. Ample supplies and stabilized prices for ethylene, much of it available as off-gas from the 99 + percent feed stock for polyethylene.
3. Continuing series of improvements in process technology have been increasing yields and reducing investment costs. Oxidation plants, which once cost 50 percent more than chlorohydrin of the same capacity, now are perhaps 10-20 percent more. Correspondingly little progress has been made in the time-tested chlorohydrin process.

TABLE 1—Ethylene Oxide—U.S. Producers and Capacities (Million Lbs./Year Early 1962)

	By Oxidation		By Chlorohydrin	Combined
Union Carbide*	Institute, W. Va.	150		
	Seadrift, Tex.	210		
	S. Charleston, W. Va.	30	40	730
	Texas City, Tex.	150		
	Torrance, Calif.	50		
	Whiting, Ind.	100		
Dow	Freeport, Tex.	....	220	
	Midland, Mich.	....	20	300
	Plaquemine, La.	....	60	
Olin	Brandenburg, Ky.	....	100	150
	Claymont, Del.	50	...	....
Jefferson	Pt. Neches, Tex.	60	70	130
Houston	Beaumont, Tex.	80	...	80
Wyandotte	Geismar, La.	60	...	60
General Aniline	Linden, N.J.	60	...	60
Calcasieu	Lake Charles, La.	60	...	60
Allied	Orange, Tex.	35	...	35
		1095	510	1605

Combined Total 1605 Million Lbs/Yr EO.
* Exclusive of 100 Million lbs/yr. capacity at Ponce, Puerto Rico.

TABLE 2—U.S. Producers and Capacities of Ethylene Glycol (Million Lbs./Year Early 1962)

Union Carbide[a]	735
Dow	330
DuPont[b]	150
Jefferson	125
Olin	125
Houston	100
Calcasieu	75
Wyandotte	65
General Aniline	35
Allied	35
	1775

[a] Plus 110 Million Lbs/Yr at Ponce, Puerto Rico.
[b] Not produced via Ethylene Oxide.

A fourth reason has been that the rapidly growing abundance of 95 percent oxygen has stimulated its use in hydrocarbon oxidation. Also, broadening opportunities for by-product nitrogen has helped the overall economics, enabling the Shell process—first used in 1958—to compete even-up with air oxidation, ready five years earlier. Recent news indicates that Union Carbide, original user of commercial oxidation, is investigating the use of oxygen at its Institute, W. Va. plant.[3]

Carbide, by far the biggest producer of EO and of glycol, also pioneered the chlorohydrin process in 1925 at South Charleston, W. Va. Even then ethylene glycol was the main use, though the first application was in the manufacture of low-freezing dynamite. With development by 1929 of suitable inhibitors, glycol began to find use in antifreeze despite its substantially higher cost over volatile alcohol products.[4]

Experimental evidence that EO could be obtained from ethylene by oxidation was reported in 1931 by Lenher.[5] Similar investigations were being made in France about this time, resulting in a patent to T. E. Lefort.[6] Later Lefort patents were assigned to Carbide, and despite lengthy litigation, these helped provide the technical basis for the first commercial oxidation plant also at South Charleston, in 1938-9.

Inasmuch as glycol markets were growing, this technological breakthrough aroused considerable interest. At least a dozen other companies began to pursue similar lines of investigation in the next 10 years. Few met success other than the oxidation processes by Scientific Design in 1953 and by Shell Chemical in 1958.

These two processes, as well as Carbide's, employ a silver catalyst in a fixed bed reactor. Fluidized processes seeking closer temperature control have also been proposed, such as that by Standard Oil of Indiana.[7] Only one fluidized process has arrived at the point of being available for license—a joint development of Atlantic Refining and Vulcan-Cincinnati.[8] Though it appears to be technologically feasible and competitive in investment cost, it has not as yet reached commercial status.

With chlorohydrin slipping and the fluidized process slow in finding takers, producers wanting to expand in EO have been choosing between the two oxidation process licensors. Aside from the plants now building, Shell's process has been in use since 1958 for Wyandotte at Geismar, La., and for Calcasieu Chemical at Lake Charles, La. Scientific Design has built plants for Allied Chemical (1954), General Aniline and Film (1958) and Jefferson Chemical (1958). Scientific Design has been far more active abroad where chlorohydrin has heretofore been the leading process due to high ethylene costs.

Union Carbide's latest move to remain kingpin in EO and glycol was its completion of the world's largest EO plant in 1959 at Ponce, Puerto Rico. (For producers and capacities see Tables 1 and 2.)

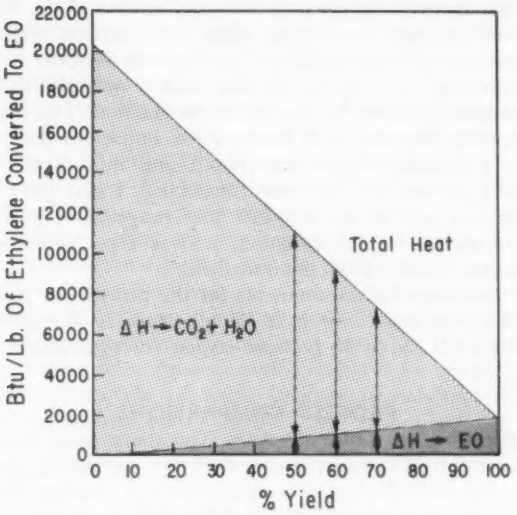

FIGURE 2—In this plot of heat evolved (Btu/pound ethylene converted) notice that the side reaction generated almost ten times as much heat at the normal expected yields.

VARIABLES OF OXIDATION

Recent progress in oxidation processing and its apparent simplicity has tended to overshadow the technical problems which had to be faced and overcome. As a 3-membered ring compound, EO is highly reactive. Under operating conditions it readily isomerizes to acetaldehyde, which is quickly converted to carbon dioxide and water. The latter reaction unavoidably consumes a portion of the ethylene feed directly.

The net reactions are:

Desired reaction: $C_2H_4 + \frac{1}{2}\,0_2 \rightarrow C_2H_4O$

Chief side reaction: $C_2H_4 + 3\,0_2 \rightarrow 2\,CO_2 + 2\,H_2O$

Though both reactions are exothermic, the side reaction generates more heat by a tenfold.[9] Even at 65 percent selectivity, for example, the side reaction produces 85 percent of the total heat. (See Figure 2).

The higher the selectivity, the less heat evolved and the simpler the problem of temperature control. Control may be considered to have three aspects:

1. Reduce the heat evolved by higher catalyst selectivity
2. Limit conversions per pass
3. Remove the heat efficiently.

Of these the first is the most important since it determines the others. For any given level of selectivity, the optimum conditions depends on the interrelationships among the process variables. For convenience, these will be considered separately.

Catalyst: Silver appears to be specific in the oxidation of ethylene to EO. Its activity and selectivity are functions of particle size, surface area, and distance between active centers for oxygen absorption. The catalyst can be prepared in a variety of ways, often modified by promoters, such as salts or oxides of alkaline earth metals. In most cases, the silver is obtained by precipitation of an insoluble silver compound, either organic or inorganic, then decomposed or reduced. Some typical examples are cited in Table 3.

Support: Catalyst supports suitable for this reaction need three desirable attributes: inertness, porosity within well-defined limits, and high thermal conductivity to carry off the heat of reaction. Alumina or corundum are most frequently mentioned, although silicon carbide and beryllia have also been patented. One of the Scientific Design catalysts describes the use of spheres of roughened surface on which the catalyst is deposited.[10] In addition, the support in a fixed-bed needs good crushing strength. In a fluidized operation abrasion resistance is equally important to minimize fines and catalyst losses, an important item since the initial catalyst charge for a 60-million-pound-per-year EO plant would cost around $500,000.

Ease of manufacture and uniformity are other points that enter into consideration. Uniformity is desirable in activity, catalyst distribution and pressure drop. One practice is to arrange the catalyst in layers of uniform activity or of gradually increasing activity in the direction of flow.

Reaction Conditions: Heat is removed from a fixed bed reactor by using a multitubed reactor consisting of many small diameter tubes surrounded by a suitable heat transfer fluid. One such reactor, that of I. G. Farben at Zweckel, has been described.[11] It contains 3,055 tubes either internally galvanized or stainless, and tapered for uniform flow. In the Shell process mild steel has been found satisfactory.

Heat transfer is accomplished in either of two ways:

- Counter current flow of the heat transfer fluid
- Boiling of the fluid under closely regulated pressure.

In the Shell process this fluid is a hydrocarbon, which is said to be stable, abundant and cheap. In Scientific Design's and other processes such fluids as diphenyl-diphenyl oxide, tetralin and other high temperature fluids are used. By means of secondary heat exchange, the oxidation reaction becomes essentially self-sufficient in steam.

The usual operating temperatures are 240-280° C. Though hot spots tend to form, with efficient temperature control the average temperature variation is about 10° C. Catalyst life often exceeds one year; to maintain activity, temperatures may be raised in the later stages. Ratio of oxygen content to ethylene ranges from 1.2-2.0, and contact time from 1-5 seconds depending on conditions and conversion.

In most operating plants the ethylene used is about 95 percent, though this is not strictly necessary. Hydrocarbon feeds as low as 50 percent could be used provided that:

1. Other hydrocarbons present do not introduce an excessive heat removal load

TABLE 3—Typical Silver Catalysts for Ethylene Oxide

Patent	Assignee	Catalysts
U. S. 2,404,438	Shell Development	Silver Oxide and Silver Oxalate, thermally reduced.
2,446,132	Shell Development	Silver and 0.5-5.0% Sodium Oxalate.
2,424,083-6	Shell Development	Pptd. Silver Oxide, dissolved in NH_3, and reduced.
2,764,598	Chempatents	Silver and lactate of Ba or Ca.
2,766,261	Chempatents	Silver and alkaline earth carboxylate.

2. Reactive impurties such as acetylene, sulfur and diolefins are below 10 ppm to avoid poisoning the catalyst, or causing possible explosive hazards.

PROCESSING

Chlorohydrin. Flow sheets for chlorohydrin and oxidation have been published.[12] In this process ethylene is first converted to ethylene chlorohydrin. The reaction is feasible because under suitable conditions, ethylene reacts faster with hypochlorous acid than with chlorine in aqueous solution.

The main reactions are:

$Cl_2 + H_2O \rightarrow HOCl + HCl$

$C_2H_4 + HOCl \rightarrow CH_2OH\text{-}CH_2Cl$

$2\,CH_2OH\text{-}CH_2Cl + CaO \rightarrow 2\,(CH_2)_2O + CaCl_2 + H_2O$

Side reactions produce ethylene dichloride and dichloethylether, and calcium chloride.

The process is carried out in two stages. In the first, chlorine in aqueous solution reacts with ethylene at a temperature of 45° C. The ethylene is maintained in excess (about 1.5 to 1), the unconverted portion being recovered and recycled. Some 95 percent of the ethylene is converted, giving chlorohydrin yields of about 85 percent.[13]

In the hydrolysis stage, the 4-5 percent chlorohydrin solution is reacted with a 10-20 percent excess of lime at 100° C. The residence time is 15-20 minutes, with ethylene oxide taken overhead as formed. The aqueous layer of the condensate, after separation, is fractionated to recover EO.

Yields. The over-all yield of EO is 80-85 percent. The salable by-products include 0.10-0.15 lbs. ethylene dichloride, 0.07-0.09 lbs. dichloroethyl ether, and 2.5-3.0 lbs. calcium chloride per pound of EO produced. On the same basis, material requirements for the process are: 0.9 lbs. ethylene, 2.0 lbs. chlorine, and 1.6 lbs. lime.

Oxidation. Regardless of specific differences in technique, the oxidation processes are basically similar as to type of silver catalyst, and to reactor design features. With either air or oxygen, the ratio of oxidizing agent to ethylene is about 1.5 to 1. However, use of oxygen permits a more concentrated feed and higher throughput.

Conversions and yields in both oxidation processes are comparable: 25-40 percent per pass and yields close to 70 percent.

Both require the presence of inerts in the feed to minimize hazards of flammability or explosion. In the Scientific Design process the inert is mostly nitrogen, and in the Shell process is mostly carbon dioxide. In the former, purging is necessary to prevent buildup of inerts in the system. This removes 15-20 percent of the ethylene, which is then converted in a second reactor under more severe one-pass conditions. The Shell process requires scrubbing to limit buildup of the carbon dioxide.

Carrying out the reaction under pressure should theoretically favor the desired main reaction. The actual benefit in the reactor is however less important than the fact it permits higher throughput and more ready recovery of the EO by water scrubbing. Usual pressures employed are in the 100-200 psig range. The product is recovered by fractionation, and is reportedly purer than the product from chlorohydrin.

Chief material requirements for the process per pound of EO produced are 1 lb. of ethylene. In the oxygen process 1.8 lbs. of 95 percent oxygen (or equivalent) are needed.

TABLE 4—End Uses of Ethylene Glycol*, Million Lbs./Year

	1950	1955	1960	1965
Antifreeze and Coolant	390	730	1020	1075
Glycol Esters/Polyesters	15	28	70	115
Cellophane	20	24	12	10
Explosives	30	33	28	30
Exports	20	52	130	75
Miscellaneous	25	35	40	45
	500	902	1300	1350

* Includes glycol from DuPont glycolic acid process.

PROCESS COMPARISONS

Oxidation vs. Chlorohydrin. The sharp trend to oxidation for EO manufacture, does not necessarily mean that the chlorohydrin process will become obsolete. More likely it will continue in a subsidiary role under favorable conditions, as in the case of Dow's expansion at Plaquemine. Four conditions favoring the use of chlororydrin are:

1. Captive production of chlorine
2. Steady sales for the by-products, especially for ethylene dichloride, used mainly as a lead scavenger with TEL, and in the manufacture of vinyl chloride.
3. Producer's intention of making propylene oxide in the same facilities, as Wyandotte does. This dual service is not currently possible with oxidation.
4. Generally less critical requirements for strength or purity of feed stock.

The main economic disadvantage of chlorohydrin processing is in raw materials cost, which are about 4¢/lb. higher than in oxidation. This is due primarily to the 2 lbs. of chlorine required per lb. of EO. Chlorine costs have risen steadily in the past 10 years. Yields in chlorohydrin are about 10 percent higher and investment is about 10-20 percent lower than with oxidation, but these advantages are narrowing. Oxidation also turns out a purer product, which is important if nonionics or fiber-grade glycol are being made.

Fixed Bed vs. Fluid Bed. The chief inherent merit in fluidized processing should be its advantage in temperature control, a feature which should permit higher yields and throughput with less hazard. However, with continued improvement in fixed bed technique the potential advantages have been reduced. Both Shell and Scientific Design previously investigated fluidized bed operation, reportedly finding it feasible but overly complex. Fluidized bed processing tends to be hampered by backmixing, and by a narrower range of operating conditions, though these drawbacks are said to have been remedied. Continued improvement in these aspects of fluidization could help make it a competitive method.

Air vs. Oxygen. Since 1958 the pros and cons of these alternatives have been vigorously debated. The question, in essence, is whether the higher throughput which oxygen makes possible, offsets the added cost of an oxygen plant. According to Scientific Design, its process

is adaptable to oxygen, but air was found to be nearly always cheaper in operating cost and capital investment.[14] Shell contends its process to be definitely more economical for capacities above 20 million lbs./yr.

All of the Shell units, built by Lummus, have been around 60 million lbs./yr. capacity. The more numerous plants by Scientific Design are somewhat smaller on the average, although the one being built for Houston Chemical will equal or top any one unit by Shell.

Processing with air requires more reactors and also higher power and equipment cost for gas handling. The oxygen process requires a carbon dioxide scrubber. At the present time, no significant cost difference would be found on the average, in one over the other. The future standing of these processes will hinge on 1) specific improvements made by each, 2) new process techniques such as fluidization or liquid phase oxidation, and 3) price trends in oxygen, including credits for by-product nitrogen.

PROCESS ECONOMICS

Continued improvements in catalyst and temperature control have resulted in gradual but steady improvement in yield. The higher selectivity is doubly important, reducing not only material requirements but also plant investment cost, because of higher throughput and less heat load for the reactor.

A cost analysis for oxidation plant investment and operation was published in 1953 by Lummus, contractor for most of the Shell oxidation plants.[15]

ETHYLENE GLYCOL PROSPECTS

While the processing alternatives have improved and clarified, the marketing aspects have become more uncertain. This applies in particular to ethylene glycol which now faces a considerable change from the conditions responsible for its rapid post-war rise in automotive antifreeze.

In 1945, ethylene glycol held less than 25 percent of the antifreeze market. By 1951 it had equalled methanol, and continuing its steady rise, captured 91 percent of the antifreeze market[16] in 1960. (See Fig. 3). Further progress can still be made at the expense of methanol, but the point of diminishing returns must soon be reached.

A second reason for glycol's rise in this market has been the overall increase in automotive demand since 1945, coupled with the trend toward larger cars until 1959. In this period the average increase in automotive market has exceeded 3 percent annually. Since 1958, this growth rate has been somewhat lower due to fluctuations in economic conditions. Also the average size of radiators has declined on new cars by some 15-20 percent, the over-all effect of the advent of compact cars and air-cooled engines.

From the standpoint of total automotive sales, the market itself should average 3 percent increase annually in the next 10 years. The two main sources of this growth should be the increase in population and increasing amount of travel. A third boost for the use of glycol would be the initiation of factory installation of antifreeze in sealed systems.

On the basis of new automotive units sold, the prospects for glycol might seem encouraging. However, many

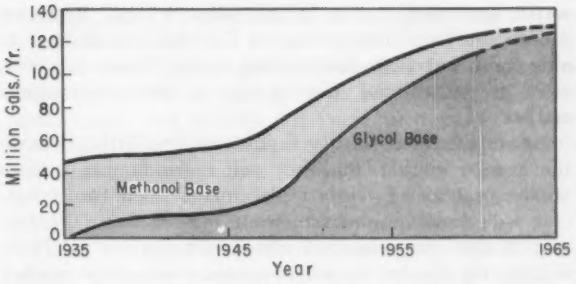

FIGURE 3—Glycol based antifreeze for automotive use has all but dominated the market leaving only 9 percent to methanol in 1960.

other trends also have a say on how this translates in glycol demand.

- **Compact Cars**—These have gained rapidly in the past three years since their introduction. The growth of compacts seems however to be slowing down. Anticipated changes for the '62 model year points to an apparent preference for intermediate size cars as the coming most popular size.
- **Air-Cooled Engines**—This trend presents a sharper challenge to glycol, but the total effect is likely to be confined to relatively few model types.
- **New Types of Engines**—On the 5-10 year horizon are the more far-reaching changes in engine design. Some of these are now on proving grounds, and economics of demand and volume production will determine their market introduction. In this period, the air-cooled gas turbines are almost certain to make their debut, at least in limited numbers, for heavy vehicles and some passenger cars. Simultaneous with the gas turbines, but counter to the trend, are likely to be some high-performance reciprocating engines which could make use of glycol for greater cooling efficiency.
- **New Cooling Techniques**—For more efficient engine cooling, ebullient heat transfer techniques may prove superior to conventional liquid flow. Dow Chemical is actively promoting this concept.

Matters of Preference. For the short term, glycol prospects will be closely linked to the motorist's ideas about antifreeze. On their past record, motorists have shown a distinct preference for the permanent-type antifreeze. However, contrary to the recommendations of the manufacturer, many have left the fluid in the radiator year-round, chancing the consequences of loss of corrosion inhibitors. Educational programs to counteract this practice have been only partially successful. For instance, a survey of motorist practice made by Du Pont, showed the following:[17]

- 62 percent completely changed fluid each winter
- 27 percent added new fluid to present fluid each winter
- 11 percent added no fluid.

Other glycol producers have made similar surveys with substantially the same results. Dow Chemical, sizing up the market, felt there might well be a demand for a multi-season antifreeze which could also serve as a radiator coolant, thereby avoiding the necessity for the winterizing servicing and spring drain. In early 1960 Dow brought out an ethylene glycol base fluid diluted with deionized

water, and used it as a full-fill radiator fluid. By heavy promotion, Dow soon prompted Carbide and DuPont to also come out with long-lasting types. These, however, were to be diluted with water in the conventional manner.

As yet these long-lasting fluids have had little effect on the annual market, but they will make further inroads on the practice of yearly replacement. Their future success will, however, be somewhat tempered by the fact that neither the producers nor service stations are likely to suddenly aim for the loss of a hard-won annual market.

Whatever volume losses are sustained by longer average use of the antifreeze product could very likely be offset in promoting glycol as a coolant for more efficient engine performance. These new market prospects would include: 1) for automobiles in summer use or in hotter climates; 2) for construction and farm equipment; and 3) for stationary engines. Dow introduced a new product for the latter in the summer of 1960.[18]

Additional glycol markets in the automotive field are expected to be found in hydraulic fluids, and in automotive air-conditioning. Non-automotive uses for glycol will be looked for in the following:

- Refrigerant for systems subject to corrosion as in breweries or ice cream plants
- Sub-surface piping for snow removal
- Sprinkler systems otherwise subject to freezing
- Hydraulic systems for machinery and equipment. The "hydrolubes" derived from glycol are used to minimize flammability problems.

Three More Outlets Slow. In addition to these extensive changes the glycol future will be affected by the fact that three of its well-established uses are showing signs of slowing down. They are:

- **Cellophane**—Glycol is used in plasticizing of cellophane film, but the market is dwindling, despite the fact that cellophane is still growing in volume. Ruling by FDA in 1958 in effect has tended to exclude ethylene glycol from its major use in food packaging.
- **Explosives**—The oldest of the commercial uses for ethylene glycol, as the dinitrate in low-freezing dynamite, continues to climb but at a slow rate. Mounting competition from ammonium nitrate will tend to restrict its future growth rate.
- **Exports**—An important outlet in the past 10 years, exports have twice exceeded 130 million lbs. annually. But due to the rise in foreign production, the overseas market will probably level off to around 50 million lbs. per year average.

Brighter Prospects. From the foregoing prospects for ethylene glycol, the overall outlook either appears dubious in some areas, or indefinite in others. The brighter side of the glycol picture is found in the polyglycols and polyesters.

Optimism regarding glycol polyesters is mostly due to the glycol-terephthalates. In these, DuPont is by far the dominant figure with its fiber and film. In 1959, DuPont more than doubled its polyester fiber capacity, which now exceeds 100 million pounds per year, polyester film capacity was increased over 30 percent. Now DuPont's supremacy is being challenged by at least three other producers: Eastman Chemical with its polyester fiber; Goodyear with a fiber and film; and Fiber Industries, with its fiber. The latter company, a Celanese-Imperial Chemical Industries joint venture, has a capacity of over 40 million pounds per year.

Markets for polyester fibers and film currently amount to about 110 million pounds yearly, which should increase to nearly 200 million pounds by 1965. The ethylene glycol requirement comes to about 80 million pounds. Introduction of polyester tire cord could add to this considerably.

Among polyglycols, diethylene glycol is the most prominent. A co-product in the hydration of EO to ethylene glycol, part of this output goes into antifreeze. However, the two growth outlets for diethylene glycol are in aromatics extraction and in dehydration of gases, natural gas in particular. An estimated 5,000 gas dehydration units using this product are now operating and steady increases are probable. Triethylene glycol also finds acceptance in the same application, often being preferred for its greater unit capacity. Triethylene glycol also holds promise in vapor disinfecting systems, for use in large public buildings. The higher polyethylene glycols are finding a great variety of specialized and growing application such as in petroleum, textiles, rubber and pharmaceuticals.

Glycol ethers are important as coupling agents and solubilizing agents, as well as solvents. They are used in many hydraulic fluids, and lately have been growing as solvents for urethanes. (See Table 7 for glycol end uses.)

PROSPECTS FOR ETHYLENE OXIDE

Mostly because of its great versatility, much of it still untapped, EO has more potential for growth in more areas than has ethylene glycol. The oxirane ring structure makes EO extremely reactive, giving high yields under controlled conditions. Reactions resulting in a long list of compounds possessing an active hydrogen.

The reaction with water to form ethylene glycol, or with glycols to form glycol ethers are examples. Reaction with ammonia leads to a mixture of three ethanolamines in varying proportions. See Figure 4 for other typical examples of reactions of ethylene oxide. The twin bases for EO growth buildup are the ethanolamines and the EO-derived nonionics.

Ethanolamines. The three ethanolamines, made by reaction of EO and ammonia, are among the most extensively used petrochemical products. They are manufactured by reaction of EO with aqueous ammonia at temperatures usually in the range of 100-200° C. Reactant ratios, pressures and contact time can be adjusted to control the relative amounts of the three ethanolamines, for plant output flexibility according to product demand.

Ethanolamine applications stem mostly from their mild and controlled alkalinity; ready reaction with fatty acids; and emulsifying and solubility properties of their soaps. Demands for the ethanolamines has shifted in the past 10 years so that each has been the most sought-after at various times. Currently the diethanolamine (DEA) is used in the largest total volume, though the largest single use has been for MEA in acid gas scrubbing. This use of MEA has been spurred by the rapid increase in facilities to purify acid gases, to recover sulfur and remove carbon

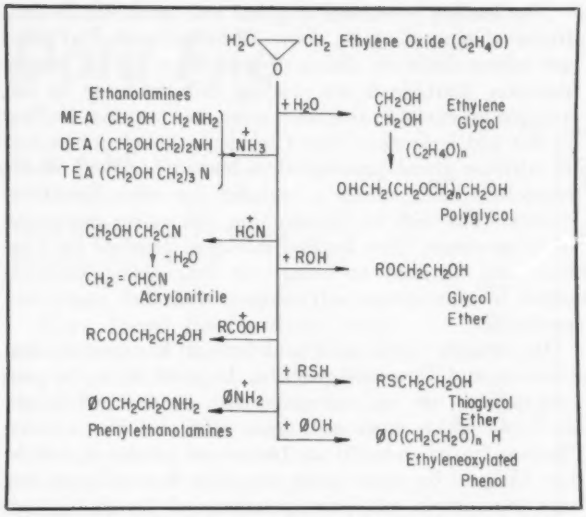

FIGURE 4—While these are all typical reactions of ethylene oxide, the twin bases for EO growth lie in ethanolamines and nonionic detergents.

dioxide. It may be used either alone or in combination with glycol, combining acid gas removal with dehydration. DEA is often used for gas scrubbing where the gases contain materials, such as carbonyl sulfide, which are irreversibly absorbed by MEA.

Another important outlet for DEA (about 3 million lbs./year) is in the manufacture of morpholine, an ingredient in wax emulsions. However, the largest use for DEA, by a wide margin, is in the booming alkanolamide nonionics for household surfactants.

Recently, TEA was the most widely used of the ethanolamines, and still is the most diversified. Its soaps are chiefly used for cosmetics and textile processing, but they are also useful in a multitude of diverse cleaning formulations, e.g., in dry cleaning, in corrosion inhibitors, and cutting fluids to name a few. The use pattern of the ethanolamines is shown in Table 5; Producers and capacities in Table 6.

Nonionics. The growth of the ethanolamines is closely linked with the rise of the nonionics. Relative latecomers on the synthetic detergent scene, the nonionics have been climbing fast. In the past two years they have furnished the impetus for the continued growth of the synthetics, while the solid synthetics (mostly alkyl aryl sulfonates) were gaining more slowly. The nonionics have grown from 70 million pounds in 1952 to 300 million pounds in 1959.[19] The first quarter of 1961 shows an increase of 13 percent over the same period in 1960.[20] They now hold 25 percent of the synthetic detergent market, and should increase their share to 30 percent by 1965.

Much of the popularity of nonionics can be traced to their growing acceptance in liquid detergents both for industrial and household use. The latter markets for nonionics is the most important.

Nonionics have an outstanding combination of properties such as: Compatibility with other types of surfactants; stability; excellent detersiveness, emulsification and wetting. Limited foaming is a general characteristic, but the alkanolamides can be made in high foaming formulation. About 75 percent of the latter go into the household product field.

The second major nonionic from EO is made by reacting varying amounts of EO with alkylphenols, of which octyl, nonyl and dodecyl are most important. These products can be made with excellent uniformity, and with properties tailored to specific needs. Unlike the alkanolamides they are low foaming and have better stability. Some 70 percent goes into industrial uses.

These two types of nonionics constitute about 80 percent of the total nonionic market. Other types include adducts with propylene oxide, with tall oil, and with fatty acid amides.

Industrial Uses. The ethyleneoxylated alkylphenols and other nonionics based on EO are actively extending the range and volume of their industrial uses. Textile processing is the leading outlet, but petroleum uses advance steadily:

- In textiles they are used in wet processing and desizing; dyeing and printing; resin treatment of cotton for wash-and-wear; and in wool scouring because of good detergency, emulsification ability, and non-substantivity.
- In petroleum, they are used increasingly for drilling muds, emulsion breakers for boosting flow rates and secondary recovery, and for acidizing treatment, as with hydrochloric acid.

Satisfying headway is being made in numerous other industrial and agricultural applications. Among these: metal processing and cleaning; commercial laundries and dry cleaning; food and beverage industries; pulping and de-inking; latex emulsions; and emulsions for agricultural chemicals.

Other Uses: Many other EO uses are well into the tonnage stage, some of them developing only in the past 2-3 years. Glycol ethers and polyethylene glycols are among the longer established products growing at a steady rate. Hydroxyethylcellulose has also shown increasing activity.

New products with considerable potential are the copolymers with propylene oxide or glycol. They are used in urethane foams; for synthetic lubricants and for heat transfer agents. EO polymers have reached the stage where Union Carbide is building a full scale plant for their manufacture.

TABLE 5—End Uses of Ethanolamines (Million Lbs./Year) (1950-1965)

	1950	1955	1960	1965
Surfactants	15	27	48	70
Gas & Oil Treating	5	21	28	38
Textiles	6	11	20	24
Cosmetics	6	9	13	16
Emulsions & Polishes	9	10	11	12
Miscellaneous	5	8	12	14
	46	86	130	174

TABLE 6—U.S. Producers and Capacities of Ethanolamines (Million Lbs./Year Early 1962)

Union Carbide	Seadrift, Tex.	60
	S. Charleston, W. Va.	50
Dow Chemical	Midland, Mich.	24
	Freeport, Tex.	6
Jefferson	Port Neches, Tex.	30
Allied	Orange, Tex.	10
Olin	Brandenburg, Ky.	10
		190

TABLE 7—End Uses of Ethylene Oxide, Million Lbs./Year

	1950	1955	1960	1965
Ethylene Glycol	305	600	905	970
Ethanolamines & Nonionics	53	145	220	295
Polyglycols & Glycol Ethers	60	115	140	195
Acrylics	25	50	70	85
Miscellaneous	15	30	55	95
	458	940	1390	1640

TABLE 8—Effect of Inerts in Oxidation (Helium vs. Nitrogen)
(U.S. 2,653,952)

	Normal System	Helium System
Tube diam	1.0 in.	1.0 in.
Catalyst depth	16 ft.	8 ft.
Pressure (atmos)	10	10
Gas Flow (NPT)	700 CFH	1000 CFH
Gas Inlet Composition Percent		
C_2H_4	5	5
CO_2	8	2
O_2	6	6
N_2	81	27
He	0	60
Conversion Percent	37	38
Yield	24	25
Selectivity	65	66
Production Ratio $\left\{\frac{\text{gms. oxide}}{\text{liter catalyst}}\right\}$	178	530

For direct EO uses, two possibilities stand out:

- As a monopropellant
- As a fumigant, EO seems a likely contender for big-time applications. It can be made non-flammable, and leaves no residual odor. In many cases a single fumigation simultaneously destroys not only insects, but molds, and bacteria. (For end use trends in EO, see Table 7.)

DEVELOPMENTS TO WATCH

The general pattern for EO and glycol will be shaped by the changes which have been described. Recent developments provide other clues on the occurrence of specific changes.

On the technical side:

- Ethylene Glycol—Improvements in the manufacturing process to obtain higher yields and greater flexibility, such as by use of ion-exchange resin catalysts.
- Ethylene Oxide—Further improvements in oxidation techniques (see Table 8); more use of process instrumentation and computer control; probable trend to enrichment with oxygen.
- Ethanolamines—Investigation in use of liquid ammonia for reaction with EO, as a possible means of reducing corrosion.

On the economic side:

- Continued high percentage of captive production, but larger amounts of EO to be shipped to small users by special tank truck.
- Trends in marketing of antifreeze such as the relative amounts sold in service outlets and in over-the-counter sales. The latter are now running about 45 percent of the total.

COMPANY DOINGS

The recognition of coming shifts in their markets has caused producers to re-examine their position and to seek logical diversification moves. These activities present another important facet in the outlook for EO and glycol, and reflects the thinking of individual companies.

The leading producers of glycol and marketers of antifreeze—Union Carbide, Dow Chemical and DuPont—are taking distinctly different approaches in the current situation. Carbide is the leading EO producer by far, and has an enviable antifreeze consumer position. DuPont is also widely known. Dow Chemical, though the second in ethylene glycol production, is less well-known, having heretofore been mostly a supplier for other antifreeze canners. But with its introduction and active promotion of its products, Dow applied sufficient pressure for Carbide and DuPont to bring out long-lasting products which to some extent will compete with their one-season products.

In broader areas of glycol use, it is expected that Carbide and Dow will probably be most active in promoting the use as a coolant and in the polyglycols. DuPont, which does not make EO and has waiting markets for its glycol in antifreeze and polyesters, will be less likely to be so active in new uses, but will probably seek to maintain its relative position.

Most of the emphasis in EO development will probably come, not from these three, but from five others of intermediate size: Jefferson, Olin, Wyandotte, General Aniline, and Allied Chemical. Their development activities are apt to center on ethanolamines, nonionics and polyethers. Direct uses for EO will also come in for increasing attention.

Two other producers, Calcasieu Chemical and Houston Chemical, expect to gear their activities largely on ethylene glycol and antifreeze, depending on their marketing connections to create an assured outlet. If this market does not grow, however, they too will ultimately seek diversification.

SUMMARY

With the entire automotive industry in a state of flux, practically all producers of EO and glycol have moved to diversify. Further major expansion is not looked for until the situation clears up. Petrochemical companies meanwhile will benefit from continued improvement in oxidation processing and from application of EO-derived products in their production and refining operations.

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[20] Chem. and Eng. News, 38, April 18, 1960, p. 52-3.

Key Words for Indexing

Antifreeze, Catalysts, Detergents, Ethanolamines, Ethylene glycol, Ethylene oxide, Oxidation, Polyesters, Polyethers, Reactors

Equipment Cost Data File

Centrifugal Pumps— Mixed Flow, Volute Type

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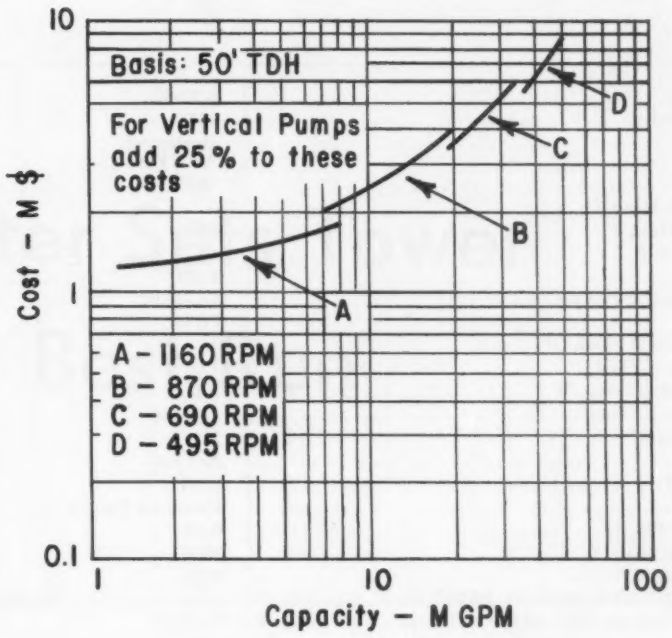
These mixed flow, volute type pumps are used primarily for capacities up to 50,000 gpm and pressures up to 100 feet when handling liquids such as found in sewage disposal, drainage, sludge removal, etc. The estimated cost of this type pump can be obtained from this curve. All pumps are standard fitted and are complete with coupling and frame but do not include the cost of a suitable drive.



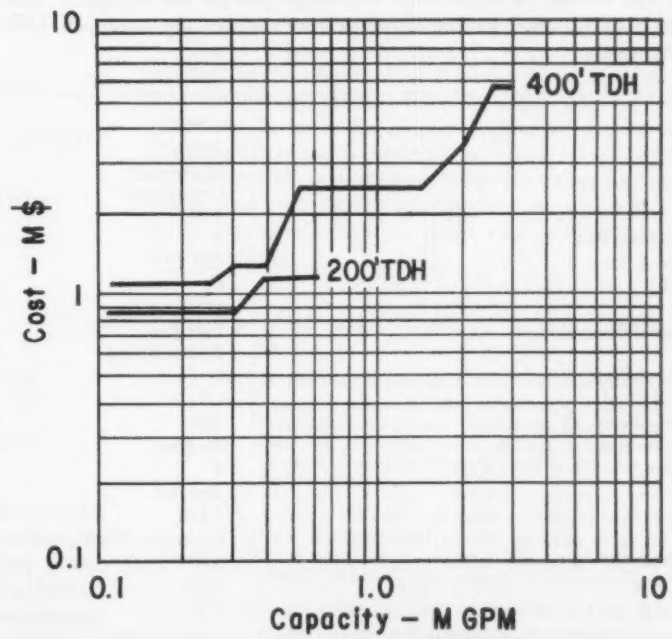
Equipment Cost Data File

Centrifugal Pumps—Multi-Stage Horizontally Split Casing

These horizontally split case units are used for high-pressure water supply, boiler feeding, etc., and are constructed for heavy, continuous duty. The two stage units employ an opposed impeller design while the three to eight stage units are equipped with all impellers in the same direction. The cost of these pumps complete with base and coupling can be estimated from this curve. The cost of a suitable drive is not included.

Key Words for Indexing

Costs
Pumps



Centrifugal Pumps—Mixed Flow, Volute Type

These costs for mixed flow, volute type centrifugal pumps are from firm vendor quotations. These prices are based on a semi-steel non-clogging casing. Impellers are cast iron, enclosed type. The impeller and shaft assembly are supported between two widely separated anti-friction bearings. Current prices for these pumps can be maintained by taking bids from time-to-time and correcting the price curves accordingly.

Date	6-20-60	6-20-60	6-20-60
M/S Index	237	237	237
Type	Horizontal Axial Flow	Horizontal Axial Flow	Horizontal Axial Flow
GPM	10,000	25,000	50,000
Suction Head, Ft.	0	0	0
Total Head, Ft.	50	50	50
Drive, H.P.	150	400	700
RPM	1160	870	495
Materials of Construction	Standard Fitted	Standard Fitted	Standard Fitted
Viscosity of Fluid, CP	1	1	1
Sp. Gr. of Fluid	1.0	1.0	1.0
Operating Temp. °F	100	150	150
Seals or Packing	Packing	Packing	Packing
No. Stages	1	1	1
Drive	Not Incl.	Not Incl.	Not Incl.
Price, $	2800	4500	9000
F.O.B.	Pensacola, Florida	Pensacola, Florida	Pensacola, Florida
Cost/GPM, $	0.28	0.18	0.18
Weight, Lbs.	3000	6800	12,000
Cost/Lb., $	0.93	0.66	0.75

Centrifugal Pumps—Multi-Stage Horizontally Split Casing

These centrifugal pump prices are from firm vendor quotations. By taking bids from time to time on similar items and correcting prices using a cost index, you can maintain a current Equipment Cost Data File. The current Marshal and Stevens cost index to be used with these prices is 237. The impellers furnished are the enclosed, non-overloading type. Shafts are generally alloy steel, however, smaller shafts are stainless steel. Shafts of larger pumps are bronze covered. The two stage pumps are equipped with ball bearings while pumps having three or more stages are equipped with ring oiling bearings.

Date	6-20-60	6-20-60	6-20-60
M/S Index	237	237	237
Type	Horizontal Centrifugal	Horizontal Centrifugal	Horizontal Centrifugal
GPM	200	1,000	3,000
Suction Head, Ft.	0	0	0
Total Head, Ft.	400	400	400
Drive, H.P.	40	125	400
RPM	1750	1750	1750
Materials of Construction	Cast Iron Bronze Fitted	Cast Iron Bronze Fitted	Cast Iron Bronze Fitted
Viscosity of Fluid, CP	1	1	1
Sp. Gr. of Fluid	1.0	1.0	1.0
Operating Temp. °F	150	150	150
Seals or Packing	Packing	Packing	Packing
No. Stages	4	2	2
Drive	Not Incl.	Not Incl.	Not Incl.
Price, $	1,160	2,550	5,750
F.O.B.	Pensacola, Florida	Pensacola, Florida	Pensacola, Florida
Cost/GPM, $	5.80	2.55	1.92
Weight, Lbs.	1,250	2,000	4,500
Cost/Lb., $	0.93	1.27	1.28

Computer Sets Tower for Best Run

Here is a case study of a search type of controller. It seeks the most profitable operation of a deisobutanizer by making a series of changes to the tower's operating variables. Even after the best operation is found, the control system continues to explore changes in order to handle any variations which may occur while the tower is running

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When variations in the uncontrolled process variables cannot be measured or when a process model cannot be constructed, a search type of optimizing control is the best type to use. In this study a deisobutanizer is instrumented so that a search controller sets the tower operating conditions for maximum profit.

The low quantity of overhead product from this deisobutanizer (300 bpd) and the slight differential value of the product over the feed ($0.40/bbl) make it unlikely that any optimizing control system would be economically justifiable for this particular installation. However, the study was undertaken to gain experience in applying a search type of control to an actual process.

HOW PROFIT IS FIGURED

In order to optimize any process, it is necessary first to define a single quantity which is to be either maximized or minimized in operating the process. It was decided that the deisobutanizer here should be operated so that a defined profit rate, P, is maximized at each instant. In calculating P, it is assumed that both the feed and the bottoms product have the same value per pound; profit results from the increased value of the iso-butane distillate over that of the feed.

The variable operating costs are the steam and cooling water costs; these are proportional to the steam flow rate, S. In this case, operating profit rate can be defined by the equation:

$$P = (V_D - V_F)\,D - V_S S \qquad (1)$$

where P is the process profit rate in unit profit per unit time.

V_D is the value per unit mass of the distillate; this value depends on the overhead composition. Normalbutane is not wanted in this stream. It is assumed that the value of the column overhead product increases linearly as the percent normal-butane decreases.

V_F is the value per unit mass of the feed. If the feed were not processed in the column, it would have value only as a motor fuel. Both the feed and column bottoms are assigned this motor fuel value.

V_S is the value per unit mass of steam plus the value of the cooling water required to condense the vapor produced by a unit mass of steam.

D is the flow rate of overhead product in unit mass per unit time.

S is the flow rate of steam in unit mass per unit time.

The defined profit rate at any instant can thus be calculated from measured value of the overhead product and steam flow rates, D and S, and the purity of the overhead product, x_D.

The task of the optimizing control is to adjust the controlled variables of the deisobutanizer so that the profit P is maximized and remains at a maximum value despite drifts caused by variations in the uncontrolled variables of the process. The uncontrolled variables of primary importance are the feed flow rate and feed composition, both of which are determined by the operation of prior processing units in the refinery.

The feed composition will drift slowly so that under typical conditions, the iso-butane content may change by approximately 20% over a period of an hour. Under upset conditions in the train of towers the rate of change may be three times this great. Other uncontrolled variables affecting the deisobutanizer are the thermal condition of the feed, the temperature and pressure of steam fed to the reboiler, the environmental conditions in the vicinity of the column.

There are four independent controlled variables which might be adjusted to optimize the deisobutanizer profit rate. Two of these are the column pressure and the particular tray on which the feed stream is introduced. The pressure has an upper limit imposed by the construction of the column and a lower limit imposed by the cooling water temperature in the condenser. Rough calculations indicate that there is little economic advantage to be gained by varying pressure within the permissible range; the pressure is, therefore, maintained constant by the feedback control loop to the overhead condenser cooling water shown in Figure 1. Although two possible feed plate locations exist on the deisobutanizer tower, it was felt that the optimizing control could be simplified without seriously affecting profit by establishing a fixed feed-plate location determined by the time-average feed composition.

The optimizing control adjusts the two remaining independent controlled variables—the steam flow rate to the column reboiler, S, and the overhead product flow, D. The reflux return to the column is the difference between the total vapor flow at the top of the column, determined by the steam flow, and the flow of overhead product. The variables S and D have the greatest effect on the profit rate produced by the deisobutanizer, and the optimum values of these flows change with variations in the uncontrolled variables—feed flow and composition.

HOW TOWER IS CONTROLLED

The deisobutanizer is a column 6 feet in diameter containing 30 trays with 2-foot spacing. On each tray there are 20 caps. These caps are of such a design that there is no overflow weir or downcomer on each tray since the cap themselves provide for the liquid flow. Originally this column was designed as a debutanizer. The column, its auxiliaries, and associated controls are shown in Figure 1.

The deisobutanizer instrumentation, sensing devices and recorder-controller are the means of communication between the optimizing control system and the process. The flow rates of both the overhead, D, and of steam, S, are measured by means of orifice plates. Two electronic transmitters with differential pressure cells provide current signals which vary linearly with the pressure drop over the orifices. Each of these two signals passes to a recorder-controller and to a device constructed to provide an output voltage signal proportional to the square root of the input current. These voltages, one proportional to the D and the other to S, are fed to the analog computer which calculates the profit rate using the relation specified in Equation 1.

The optimizing system provides two output current signals which establish the set points for controllers which regulate D and S. The controllers send out current signals to transducers which in turn supply variable air pressure to operate diaphragn valves on the overhead product and steam lines. Switches mounted on both valves detect when the valve is open beyond a fixed upper limit or closed beyond a fixed lower limit. Signals from these switches are fed back to the optimizing control so that it is made aware if it makes valve adjustments which might result in D or S values outside predetermined limits. In the case of overhead product, the switches are set to indicate the full-open and full-closed positions of the valve. In the case of steam, the switches are placed to prevent flooding the column by too high a steam flow or to avoid excessively low values of x_D by too small a steam flow.

The other signal passing from the process to the optimizing control is x_D, the fraction of iso-butane in the overhead product. This is measured by a chromatograph which sampled the overhead once every 10 minutes. The device preformed the chromatographic separation and measured the thermal conductivity of the separated stream. The output was a continuous voltage which exhibited a peak associated with each component. A timer and memory circuit, designed by J. R. Wright of the Sun Oil Company, accepted this voltage and held the peak voltages associated with normal butane and iso-butane until a new value for each was obtained ten minutes later. The mol fraction of iso-butane in the mixture was assumed to be proportional to the height of its peak. This on-stream analyzer was checked several times during each run by taking stream samples and analyzing them with a laboratory chromatograph.

WHAT OPTIMIZING RUNS SHOW

Seven optimizing runs of various length have been made with an optimizing control adjusting the steam flow, S, and the overhead product flow, D. Sections from

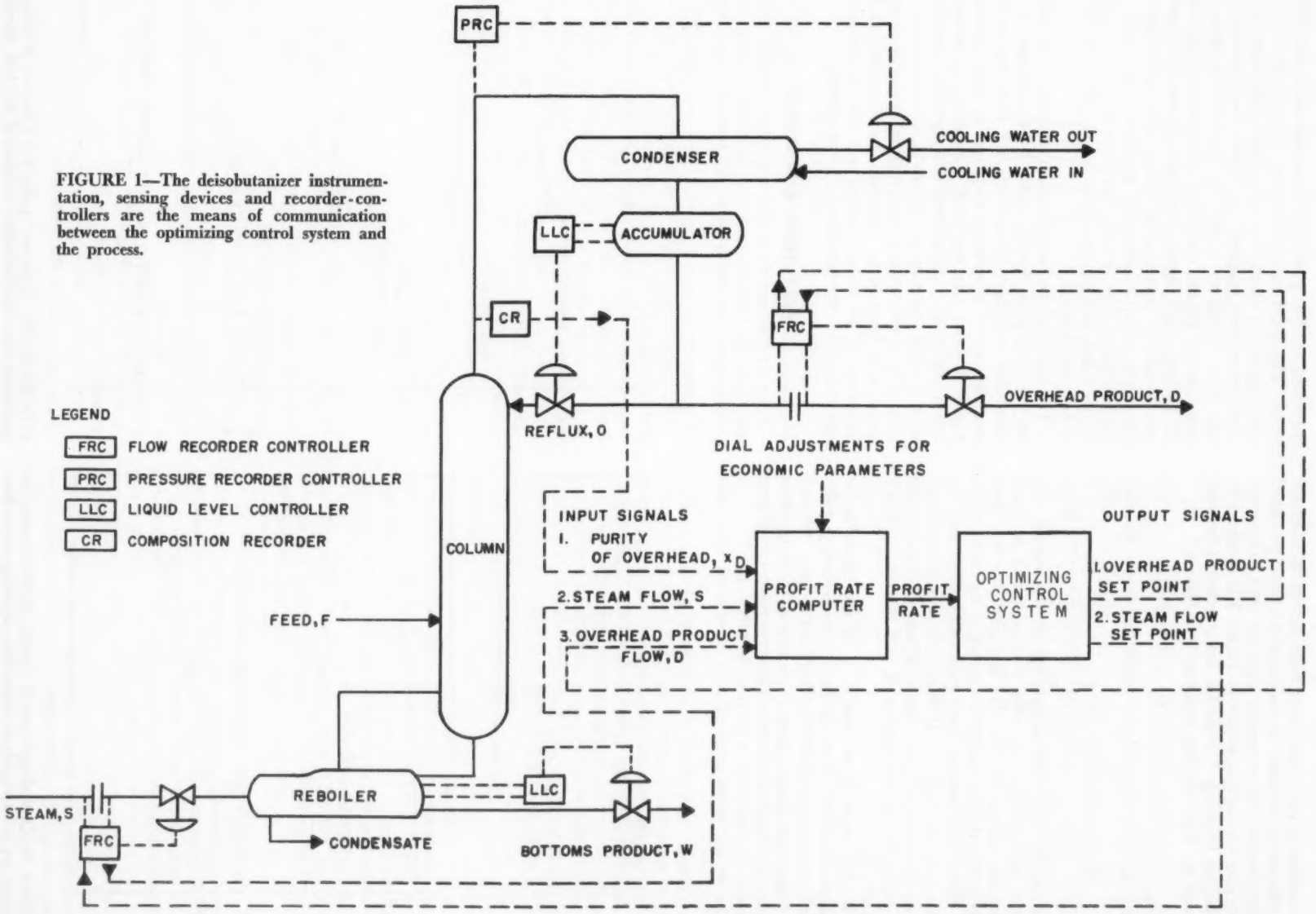

FIGURE 1—The deisobutanizer instrumentation, sensing devices and recorder-controllers are the means of communication between the optimizing control system and the process.

the records of these runs have been chosen to illustrate how the system operated to maximize the profit produced by the process. The numerical equation used to compute profit rate for the run shown in Figure 2 is obtained by combining Equation (1) with a linear relation between V_D and x_D. The resulting equation is as follows:

$$P = (0.55\,x_D - 0.15)(D) - (0.5)(10^{-3})(S) \qquad (2)$$

Initially $x_D = 0.67$, $D = 13.2$, $S = 10{,}400$ and thus by Equation (2)

$$P = [(0.55)(0.67) - 0.15][13.2] - (0.5)(10^{-3})(10{,}400) = -2.3$$

Before the optimizing control system was started, the column was allowed to come to equilibrium at some reasonable values of S and D. The controller was then connected to the process; it first averaged the profit signal and stored this average profit rate value in its memory (see move 0 of Figure 2). It then made a move by changing the electrical set point signals to controllers adjusting the steam flow to the reboiler, S, and overhead product take-off, D.

The first move is arbitrarily set by the circuit to be an increase in both S and D. Since it is assumed that the initial operating conditions are adjusted to those believed to be most profitable, there is no reason to make other than an arbitrary first move. This first move (see Figure 2, move 1) resulted in a decrease in profit, P.

The second move returned S to its original value and decreased D. The profit rate remained below its original value. The third move increased D and decreased S, resulting in an increased profit rate. The same move combination was repeated, and profit rate continued to rise. This section of a run was included to show the initial search for the optimum. After move 7, the steam hit its lower limit, its step size was reduced after several moves, and subsequent small moves were made near the limit. The control meanwhile continued the search for the best value of D, reduced the move size in the vicinity of this value, and continued the search with small moves of both variables.

The utility of the control system, however, is in adapting operating conditions to either sudden changes in uncontrolled variables—in this case the feed flow rate or composition—or to gradual variations in these variables. Figure 3 shows the results of a sequence of moves in which the control approached new optimum conditions after a rapid decrease in the iso-butane content of the feed. The deterioration of feed quality inevitably brought about a decrease in x_D. However, by decreasing D and increasing S, the control system was able to increase x_D and re-establish the profitability of the process.

EARLY TESTS AID SYSTEM

Prior to the time when the optimizing control was attached to the process, tests and calculations were made to determine the steady-state and transient behavior of

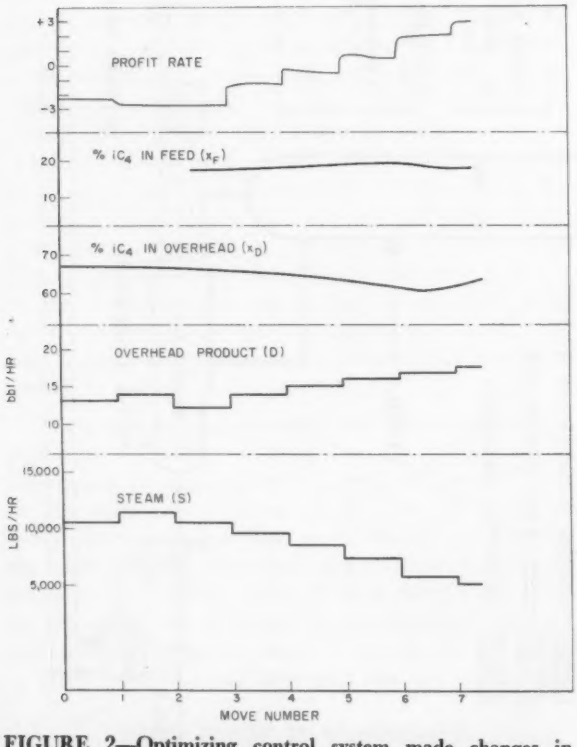

FIGURE 2—Optimizing control system made changes in electrical set point signals to controllers adjusting steam flow to the reboiler, S, and the overhead product take-off, D.

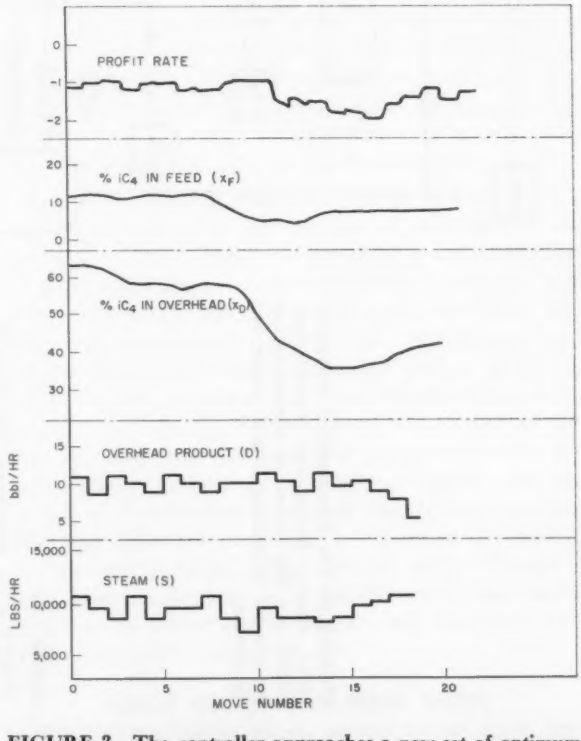

FIGURE 3—The controller approaches a new set of optimum conditions when the iso-butane content of the feed decreases.

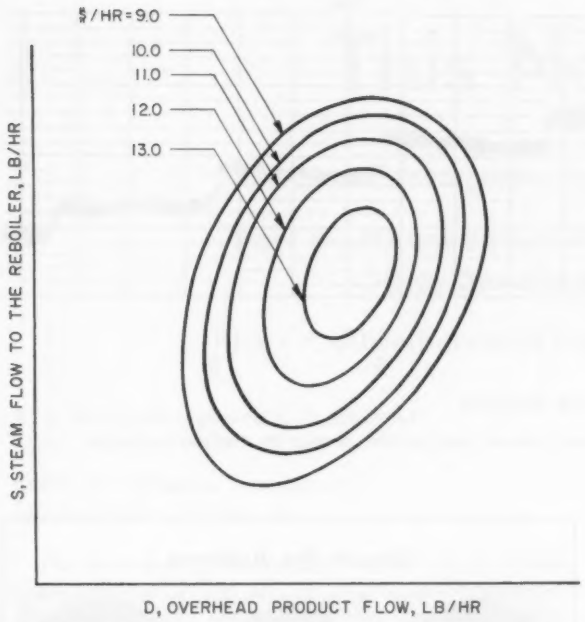

FIGURE 4—These are the profit contours for the case study described here.

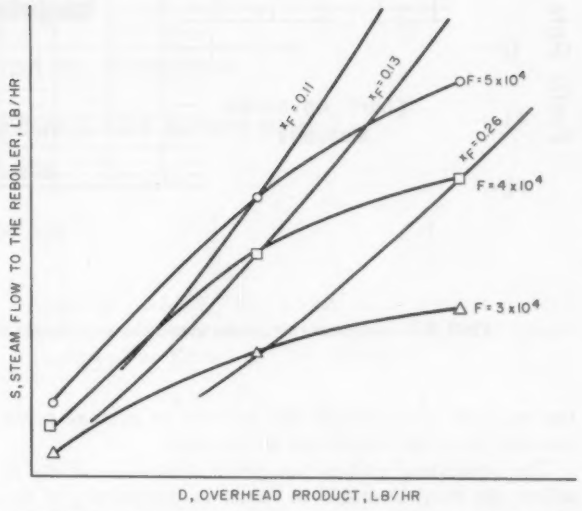

FIGURE 5—Feed quantity and composition determine the location of the optimum operating conditions.

the deisobutanizer. Such information is not necessary to the design and construction of the control system but it does aid in setting the various parameters of the control and in interpreting the results of the experimental runs.

The plate-to-plate distillation calculation programed by Bonner[1] was employed to determine the form of a correlation between the overhead composition, x_D, and the feed composition, x_F, the feed flow, F, the steam flow rate, S, and the overhead product flow rate, D. The following equation was found to represent the computer-calculated data with a maximum error of 5%.

$$x_D = 5.96\,x_F - 9.37\,x_F^2 + (0.799)(10^{-2})(S/F) - (0.348)(10^{-4})(S/F)^2 - 2.62\,(D/F) - 0.040 \quad (3)$$

where S is expressed in lb/hr and D and F in bbl/hr.

Data obtained in operating the deisobutanizer was in good agreement with this equation.

By combining Equation (3) with the profit Equation (1), it is possible to predict profit contours for given values of F and x_F (see Figure 4). The values of S and D for maximizing profit can be determined from this mathematical model for any values of F and x_F. The results of such a calculation are shown in Figure 5.

The transient response of the column was also determined by a set of tests. Both frequency response and step response data were obtained to characterize the dynamic behavior of the column.

The hydrodynamic response of the column was rapid. For example, an increase in the feed flow rate was reflected by an increase in bottoms flow after a delay of about 1 minute and with a first-order time constant of about 8 minutes. A decrease in steam flow caused a decrease in reflux within 3 to 4 minutes. A change in pressure brings about changes in flows throughout the column. A lowering of the pressure causes sudden liquid flashing. The resulting vapor bubbles are distributed throughout the liquid and increase its apparent volume. There are increases in liquid levels and thus of liquid flows. This effect occurs rapidly and persists for some 10 to 15 minutes after the pressure change.

All preliminary tests indicated that the response of the overhead product composition, x_D, to changes in the operating conditions of the deisobutanizer is very slow. The time required for x_D to reach a steady-state value after a change in F, x_F, S, or D is in excess of 2 hours. One explanation for this rather long time is the large capacity of the two overhead accumulators—about 50 barrels, when they are half full. The liquid hold-up of the column is 53 barrels and of the reboiler and tower bottom, 18 barrels. This combined hold-up is approximately equivalent to one hour's feed flow.

DESIGNED FOR IMPROVED PERFORMANCE

Due to variations in the electrical signals representing the flow quantities, S and D, there was appreciable noise in the calculated profit. Figure 6 shows an actual chart obtained from the profit recorder for the optimizing run shown in Figure 2. The period of the fluctuations was approximately three minutes; the amplitude varies somewhat with time. The control averaged this profit signal for ten minutes to reduce the effect of noise. The averaging technique and length of time selected were successful in that apparently correct decisions about the success or failure of a move were made despite the confusion of noise. Move 1 on Figure 6 was judged to be a failure,

COMPUTER SETS TOWER FOR BEST RUN . . .

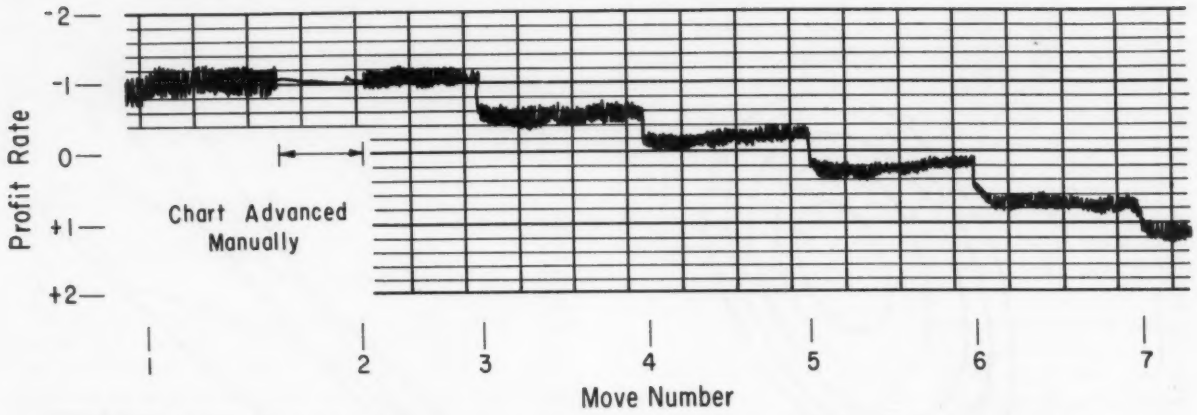

FIGURE 6—Correct decisions above the success or failure of a move were possible despite the confusion of noise.

for example, even though the decrease in average profit was less than the amplitude of the noise.

The optimizing control has demonstrated its ability to adjust the flows D and S to values in the vicinity of the economic optimum within 6 to 10 moves. If abrupt changes in feed flow, F, and feed composition, x_F, occur no more frequently than this, the control operates with a minimum of confusion and has the ability to maximize profit. It has been observed, however, that sometimes there are steady drifts in F or more especially x_F which foil the control strategies because their effect on profit during successive moves is greater than the effect of the control adjustments of D and S.

Two means of improving performance during periods of rapid drift or frequent fluctuation in F or x_F are under consideration. First, modification of the tower and its auxiliaries to speed-up the dynamic response of the system will decrease the move time and thus decrease the effect of drift on profit during a move. The control will follow the most rapid drift observed in this investigation if the equilibrium time of the process could be reduced to about 30 minutes. Second, adjusting by optimizing control, the ratio of D/F and S/F rather than D and S will lead to more rapid optimization in the case of a rapid fluctuation of feed flow, F. An increase in F, for example, will bring about immediate corresponding increases in D and S; overhead product purity x_D should not change appreciably. The control would then perform fine trimming to arrive at the point of maximum profit by making small adjustments in the two flow ratios. Similarly, D and S can be correlated to x_F to compensate for abrupt changes in the variable, and again the control moves may be viewed as trimming adjustments.

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[1] IBM Reference Manual, "Plate-to-Plate Distillation Calculations on the 650 Computer," Form 820-4008.

Key Words for Indexing

Computers, Controllers, Distillation, Economics, Instrumentation, Profits

About the Authors

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Figure Separations This New Way

Part 5–A Convergence Method for Absorbers

Part 6–Minimization of Round-Off Errors and Other Developments

Part 7–Absorbers with Reboilers

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The Θ-method of convergence can be refined to minimize round-off errors and to include developments in the calculation of conventional and complex columns. The need for this was apparent in the extension of this method to absorbers, (Part 5). These developments include the detection and treatment of separated components, use of the bubble point procedure for all hydrocarbon systems, and the constant-composition method for enthalpies.

MINIMIZE ROUND-OFF ERROR

Material balances may be written around either end of a conventional distillation column and any given plate. In Part 1, it was suggested that these balances be written around the top of the column for all plates above the feed plate and around the bottom for the feed plate and all plates below it. The results given in Table 1 show that this calculational procedure minimizes the round-off error for a conventional column. These results are based on the use of the following equations. When material balances are written around the top of the column and any plate j in either the rectifying or stripping section, the following equations are obtained.

$$\frac{v_{1i}}{d_i} = A_{oi} + 1, \text{ (balance around condenser)} \qquad (1a)$$

$$\frac{v_{ji}}{d_i} = A_{j-1,i}\left(\frac{v_{j-1,i}}{d_i}\right) + 1, 2 \leqq j \leqq f-1 \qquad (1b)$$

$$\frac{\bar{v}_{fi}}{d_i} = A_{f-1,i}\left(\frac{v_{f-1,i}}{d_i}\right) + 1 \qquad (1c)$$

$$\frac{v_{ji}}{d_i} = A_{j-1,i}\left(\frac{v_{j-1,i}}{d_i}\right) + \left(1 - \frac{FX_{Fi}}{d_i}\right), f+1 \leqq j \leqq N+1 \qquad (1d)$$

For a given set of L/V's and K's, the calculations may be carried out through Equation (1c). Before the calculations indicated by Equation (1d) may be performed, the quantity $(1 - FX_{Fi}/d_i)$ must be evaluated. By an over-all material balance, this quantity is equal to $(-b_i/d_i)$ for which an expression is developed by a substitutional process in the same manner as shown for Equation (29) of Part 1.

$$\frac{b_i}{d_i} = \frac{\left[\left(\frac{l_{f-1,i}}{d_i}\right) + \frac{l_{Fi}}{FX_{Fi}}\right]\omega_i}{\Omega_i + \omega_i\left(\frac{v_{Fi}}{FX_{Fi}}\right)} \qquad (2)$$

$$\omega_i = A_{N+1,i}\,A_{Ni}\cdots A_{f-1,i}\,A_{fi}$$

$$\Omega_i = 1 + A_{N+1,i} + A_{N+1,i}\,A_{Ni} + \cdots\cdots + A_{N+1,i}\,A_{Ni}\cdots A_{f+1,i}\,A_{fi}$$

When material balances are written around the bottom of the column and any given plate, the following equations are obtained.

$$\frac{l_{Ni}}{b_i} = S_{N+1,i} + 1, \text{ (balance around reboiler)} \qquad (3a)$$

$$\frac{l_{j-1,i}}{b_i} = S_{ji}\left(\frac{l_{ji}}{b_i}\right) + 1, f+1 \leqq j \leqq N \qquad (3b)$$

$$\frac{\bar{l}_{f-1,i}}{b_i} = S_{fi}\left(\frac{l_{fi}}{b_i}\right) + 1 \qquad (3c)$$

$$\frac{l_{j-1,i}}{b_i} = S_{ji}\left(\frac{l_{ji}}{b_i}\right) + \left(1 - \frac{FX_{Fi}}{b_i}\right), 1 \leqq j \leqq f-1 \qquad (3d)$$

Before Equation (3d) may be applied, it is necessary to evaluate the term $(1 - FX_{Fi}/b_i)$ or its equivalent

TABLE 1—Round-Off Error Given by Different Calculational Procedures for Conventional Columns

(For all cases shown N = 10, the column has a partial condenser and a reboiler, thermal condition of the feed is boiling point liquid and the absorption factor, A, remains constant throughout the column.)

Case No.	Location of Feed Plate	Absorption Factor A	Match at Plate No. 11 (b/d) stepwise by Eq. (1) (b/d) formula*	Match at Plate No. 1 (b/d) stepwise by Eq. (3) (b/d) formula
1	11	1.0000000	1.0000	1.0000
2	11	0.095555555	1.0000	0.9044
3	11	9.5555555	1.0000	1.0000
4	1	9.5555555	-4.0388×10^8	1.0000
5	1	0.095555555	1.0000	1.0000
6	1	1.00000000	1.0000	1.0000

* Value of (b/d) given by Equation (5) agreed to within seven or eight digits out of a possible eight with the values given by Equations (2) and (4).

$(-d_i/b_i)$. The following expression for b_i/d_i was developed in Part 1 from the material balances represented by Equation (3).

$$\frac{b_i}{d_i} = \frac{\Phi_i + \phi_i \left(\frac{l_{Fi}}{FX_{Fi}}\right)}{\left(\frac{v_{fi}}{b_i} + \frac{v_{Fi}}{FX_{Fi}}\right)\phi_i} \qquad (4)$$

where,

$$\phi_i = S_{oi}\, S_{1i} \cdots\cdots S_{f-2,i}\, S_{f-1,i}$$

$$\Phi_i = S_{oi}\, S_{1i} \cdots\cdots S_{f-3,i}\, S_{f-2,i} + \ldots\ldots + S_{oi} + 1$$

When Equation (1) is applied from the top of the column to the feed plate and Equation (3) is applied from the bottom to the feed plate, the quantities needed for the calculation of b_i/d_i by the following formula will have been obtained.

$$\frac{b_i}{d_i} = \frac{\left(\frac{l_{f-1,i}}{d_i}\right) + \left(\frac{l_{Fi}}{FX_{Fi}}\right)}{\left(\frac{v_{fi}}{b_i}\right) + \left(\frac{v_{Fi}}{FX_{Fi}}\right)} \qquad (5)$$

For any given set of L/V's and K's, the three expressions for b_i/d_i are equivalent, as shown in the Appendix. It is also shown that for any given set of L/V's and K's Equations (1) and (3) give the same set of flow rates throughout the column. Thus any difference between the v's (or l's) obtained by different calculational procedures may be attributed to round-off error.

Equations (2), (4) and (5) were not subject to any appreciable round-off error. The values of b_i/d_i computed by these formulas agreed to within seven or eight digits out of a possible eight. After b_i/d_i has been calculated, Equations (1) and (3) may be applied throughout the column. In order to obtain a measure of the round-off error incurred by the application of these equations, the quantity b_i/d_i was also computed by the stepwise calculational procedure.

For example, suppose Equation (1) has been applied in a stepwise manner from the top of the column to the bottom to give $v_{N+1,i}/d_i$. Then the value of b_i/d_i as given by the stepwise calculations is equal to $A_{N+1,i}(v_{N+1,i}/d_i)$. This procedure may be referred to as "matching at the bottom of the column."

The effect of round-off error was investigated by solving several relatively simple examples. These results, given in Table 1, show that round-off error is minimized for a conventional column when calculations are made down from the top of the column to the feed plate and up from the bottom of the column to the feed plate, referred to as "matching at the feed plate." Large errors were encountered when the flow rates in the stripping section for a very heavy component were calculated by material balances written around the top of the column, Case 4. Similarly, when the flow rates for a very light component in the rectifying section were calculated by material balances which included the bottom of the column and the given plate, large errors resulted also, Case 2. The round-off error results from the negative terms, $(1 - FX_{Fi}/d_i)$ and $(1 - FX_{Fi}/b_i)$, which appear on the right-hand sides of Equations (1) and (3), respectively.

Generally the round-off error is small when calculations past the feed plate to the top and bottom of the column are made for very heavy and light components, respectively, as shown by cases 3 and 5. In each instance the negative term mentioned previously is relatively small, numerically, compared with the other terms in the equations.

The calculational procedures described for conventional columns makes use of a numerical process sometimes referred to as "nesting." Instead of using nesting, a general formula for v_{ji}/d_i may be employed. It is developed by the substitutional process whereby the expression for v_{ji}/d_i is substituted successively into the one for $v_{j+1,i}/d_i$ and the term $(1 - FX_{Fi}/d_i)$ is replaced by its equivalent $(-b_i/d_i)$. By application of the formula so obtained, round-off error may be nearly eliminated for conventional columns. However, this procedure did not eliminate round-off error when it was extended to complex columns.

The effect of round-off error associated with various calculational procedures for a complex column with two feed plates was examined in a manner analogous to that shown for conventional columns. As in the case of conventional columns, the most accurate flow rates below the top and above the bottom feed plate are obtained by making calculations down from the top and up from the bottom of the column, respectively. Thus, the problem to be resolved for complex towers is whether the flow rates between the top and bottom feed plates should be computed by use of material balances that include the top or the bottom of the column.

Any difference between the values obtained for a particular flow rate by different calculational procedures may be attributed to round-off error because it can be shown in a manner similar to that given for conventional columns that the expressions for a given flow rate (obtained by writing material balances around the top and the bottom of the column) are equivalent. Similarly, all of the expressions which may be developed for b_i/d_i are equivalent.

Several simple examples were solved and the results obtained are given in Table 2. These results show that if a component enters the column in only one feed, the most accurate calculational procedure consists of making calculations down from the top and up from the bottom of the column to the given feed plate at which the particular component enters. For components which enter in both feeds, no simple generalization exists. When a component enters the column in each of several feeds, the most accurate calculational procedure may be determined by carrying out the ratio test for each feed plate as shown in Table 2.

Only one expression is needed for the computation of b_i/d_i since expressions corresponding to matching at each of the feed plates were found to be almost independent of round-off error. When side-streams are considered, the conclusions are not altered. This results from the fact that the quantities corresponding to the side-streams appear in the material balances as positive terms. In columns with a large number of plates,

round-off error could become appreciable in the addition process, say in the calculation of $l_{t-1,i}/d_i$ by the nesting procedure. This may be partially rectified by ordering the addition of the terms of the series (see Equation (32) in the Appendix) according to size, the smallest term being first.

SEPARATED AND SINGLE PHASE COMPONENTS

Single phase light and heavy components are treated in the same manner as shown in Part 5. For a conventional column, separated components are defined as those which leave the column in only one product stream, the distillate or bottoms. They are detected in several ways. If b_i/d_i is less than some small preassigned number (the order of magnitude of the lower limit of the computing machine), the component is said to be a "separated light" component. For such a component in a conventional distillation column, $b_i = 0$ and $d_i = FX_{Fi}$. Similarly, if b_i/d_i is equal to or greater than some large number of the same magnitude as the upper limit of the computing machine, the component is said to be a "separated heavy" component and for such a component, $d_i = 0$ and $b_i = FX_{Fi}$.

For a separated light component, the flow rates above the feed plate are calculated by Equation (1) in the usual manner. The flow rates below the feed plate are also computed by continued application of Equation (1). It is to be observed that a simplification is obtained because the term $(1 - FX_{Fi}/d_i)$ is equal to zero. Good accuracy may be expected since the negative term $(1 - FX_{Fi}/d_i)$ which gave the round-off error for the examples shown in Table 1 is equal to zero. Similarly, for a separated heavy component, the flow rates below the feed plate are given by application of Equation (3) in the usual manner. Also, above the feed plate, use of Equation (3) is continued and again a simplification results since $(1 - FX_{Fi}/b_i) = 0$.

Separated light components may also be detected in making calculations from the bottom of the column toward the feed plate. If in this process, a j is found such that l_{ji}/b_i is greater than some large preassigned number, the component may be considered as a separated light component and treated as described previously. This amounts to taking $b_i/d_i = 0$, which results in little error. It is shown in the Appendix that if a j exists such that

$$\frac{l_{ji}}{b_i} \geqq \rho \tag{6}$$

where,

ρ = a large number of the order of magnitude of the upper limit of the machine,

then for a component for which all of the S_{ji}'s are greater than unity

$$\frac{b_i}{d_i} < \frac{f+1}{\rho} \tag{7}$$

The right-hand side of equation (7) is approximately the same order of magnitude as the lower limit of the machine and may be taken equal to zero.

Similarly, if in making calculations down from the top, a j for a heavy component is found such that v_{ji}/d_i is greater than ρ, it may be shown in a manner analogous to that used for Equation (7) that b_i/d_i is of the same order of magnitude as ρ. Thus d_i may be taken equal to zero. Equation (3) is applied for the calculation of the flow rates both above and below the feed plate. Again a simplification results because $(1 - FX_{Fi}/d_i)$ is equal to zero.

In the treatment of separated components in complex columns, it is convenient to consider two general classifications of these columns. In the first class are included those columns with multiple feeds and only two streams withdrawn, the distillate and bottoms. The second class consists of those columns with multiple feeds and one or more side-streams withdrawn other than the distillate and bottoms. The treatment of separated components in the first class follows very closely that described for conventional columns. For example, suppose a separated light component is detected below the lower feed plate. Then for this component, the distillate rate is known, since

$$d_i = F_1 X_{F1i} + F_2 X_{F2i} = FX_{Fi} \tag{8}$$

Calculations may be made from the top of the column past the lower feed plate and toward the bottom by use of equations similar in form to Equation (1).

However, for columns of the second class, the detection of a separated component does not lead to the simplifications found for the first class. That is for a separated light component, it follows that $b_i = 0$. However, the value of d_i does not follow immediately as in the case of complex columns of first class. Further calculations must be carried out before d_i may be evaluated. For purposes of illustration, consider a column having two feed plates, located f and t $(t > f)$ plates from the top as shown in Figure 1. Component i enters at both plates f and t at the rates F_1X_{F1i} and F_2X_{F2i}, re-

TABLE 2—Round-Off Error Given by Different Calculational Procedures for Complex Columns

(For all cases shown N = 10, the column has a partial condenser and reboiler, thermal condition of each feed is boiling point liquid, A remains constant throughout the column and no streams withdrawn other than the distillate and bottoms. Feed F_1 enters on Plate No. 1 and Feed F_2 enters the column on Plate No. 11 for all cases.)

Case No.	F_1X_{F1} and F_2X_{F2}	Absorption Factor A	Match at Top Feed Plate (b/d) Stepwise (b/d) Formula	Match at Bottom Feed Plate (b/d) Stepwise (b/d) Formula
1	$F_1X_{F1} = F_2X_{F2}$	9.5555555	1.0000	0.5554
2	$F_1X_{F1} = 2F_2X_{F2}$	9.5555555	1.0000	8.6634×10^6
3	$F_1X_{F1} = \frac{F_2X_{F2}}{2}$	9.5555555	1.0000	0.7991
4	$F_2X_{F2} = 0$	9.5555555	1.0000	-4.0388×10^9
5	$F_1X_{F1} = 0$	0.095555555	0.9044	1.0000
6	$F_1X_{F1} = F_2X_{F2}$	0.095555555	-1.0180×10^{-8}	1.0000
7	$F_1X_{F1} = 2F_2X_{F2}$	0.095555555	-9.1285×10^{-8}	1.0000
8	$F_1X_{F1} = \frac{F_2X_{F2}}{2}$	0.095555555	3.1819	1.0000
9	$F_1X_{F1} = F_2X_{F2}$	1.0000000	1.0000	1.0000

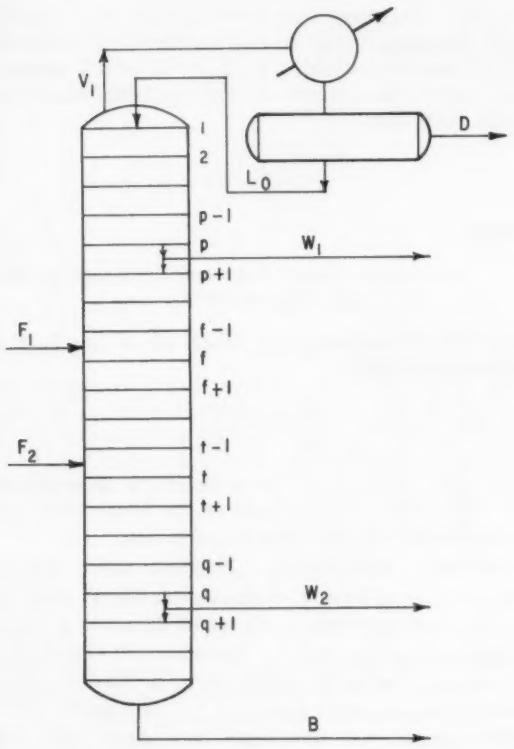

FIGURE 1—Complex column with two feed plates and two side streams.

spectively. Two side-streams are withdrawn at the rates W_1 and W_2 from plates p and q ($p < f, q > t$), respectively.

The calculational procedure to be followed for a separated light component in a complex column such as the one shown in Figure 1 follows. A separated component may be detected as described previously for conventional columns. Suppose a separated light component is detected in the process of making calculations up from the bottom of the column toward the lower feed plate t; that is a j is found such that $l_{j1}/b_1 > \rho$. As in the case of conventional columns, it is readily shown that b_1/d_1 is near the lower limit, $1/\rho$, and may be taken equal to zero. All ratios of the flow rates obtained for the given component by making calculations up from the bottom of the column are discarded. For such a component, all material balances are written around the top of the column and any given plate. Calculations are carried out in the usual manner to the feed plate f to give values for w_{11}/d_1 and $l_{f-1,1}/d_1$. For the feed plate f and all plates below, the material balances for a separated component are as follows:

$$\frac{v_{f1}}{d_1} = \frac{l_{f-1,1}}{d_1} + \frac{l_{F11}}{d_1} + C_{11} - \frac{F_1 X_{F11}}{d_1} \qquad (9a)$$

$$\frac{v_{j+1,1}}{d_1} = A_{j1}\left(\frac{v_{j1}}{d_1}\right) + C_{11} - \frac{F_1 X_{F11}}{d_1}, f \leqq j \leqq t-2 \qquad (9b)$$

$$\frac{v_{t1}}{d_1} = \frac{l_{t-1,1}}{d_1} + \frac{l_{F21}}{d_1} - \frac{w_{21}}{d_1} \qquad (9c)$$

$$\frac{v_{j+1,1}}{d_1} = A_{j1}\left(\frac{v_{j1}}{d_1}\right) - \frac{w_{21}}{d_1}, t \leqq j \leqq q-1 \qquad (9d)$$

$$\frac{v_{q+1,1}}{d_1} = \left(\frac{L_q - W_2}{L_q}\right)\left(\frac{l_{q1}}{d_1}\right) \qquad (9e)$$

$$\frac{v_{j+1,1}}{d_1} = A_{j1}\left(\frac{v_{j1}}{d_1}\right), q+1 \leqq j \leqq N \qquad (9f)$$

where,

$$C_{11} = 1 + w_{11}/d_1$$

Before further calculations may be performed, it is necessary to evaluate w_{21}/d_1 and d_1. The expression for w_{21}/d_1 is developed in an analogous manner to that shown for Equation (71) of Part 3. From the upper feed plate, f, to the lower one, t, a substitutional procedure is followed whereby the expression for v_{j1}/d_1 is substituted successively into the one for $v_{j+1,1}/d_1$ to give

$$\frac{l_{t-1,1}}{d_1} = \omega_{f1}\left(\frac{l_{f-1,1}}{d_1} + \frac{l_{F11}}{d_1}\right) + \Omega_{f1}\left(C_{11} - \frac{F_1 X_{F11}}{d_1}\right) \qquad (10)$$

where,

$$\omega_{f1} = A_{t-1,1} \cdots A_{f1}$$

$$\Omega_{f1} = A_{t-1,1} + A_{t-1,1}A_{t-2,1} + \cdots + A_{t-1,1} \cdots A_{f1}$$

Between plates t and q, the same procedure leads to

$$\frac{l_{q1}}{d_1} = \omega_{t1}\left(\frac{l_{t-1,1}}{d_1} + \frac{l_{F21}}{d_1}\right) - \Omega_{t1}\left(\frac{w_{21}}{d_1}\right) \qquad (11)$$

where,

$$\omega_{t1} = A_{q1} \cdots A_{t1}$$

$$\Omega_{t1} = A_{q1} + A_{q1}A_{q-1,1} + \cdots + A_{q1} \cdots A_{t1}$$

The unknown d_1 may be eliminated from Equations (10) and (11) by use of the result obtained by an overall material balance,

$$d_1 = \frac{FX_{F1}}{C_{11} + \frac{w_{21}}{d_1}} \qquad (12)$$

Since $l_{q1}/d_1 = (L_q/W_2)(w_{21}/d_1)$, Equations (10), (11) and (12) are readily solved for w_{21}/d_1 to give

$$\frac{w_{21}}{d_1} = \frac{\omega_{t1}\left[\omega_{f1}\left(\frac{l_{f-1,1}}{d_1}\right) + \Omega_{f1}C_{11}\right] - Z_1}{\frac{L_q}{W_2} + \Omega_{t1} + Z_1} \qquad (13)$$

where,

$$Z_1 = \frac{\omega_{t1}\left[\Omega_{f1}F_1X_{F11} - \omega_{f1}l_{F11} - l_{F21}\right]}{FX_{F1}}$$

After w_{21}/d_1 has been evaluated by use of Equation (13), d_1 is computed by Equation (12). Then calculations may be carried out toward the bottom of the column by use of Equation (9) until a j is found such that $v_{j1}/d_1 \; 1/\rho$.

The calculational procedure described is readily extended to include the case where any number of side

streams are withdrawn. The treatment of separated heavy components is analogous to that described for separated light components.

CALCULATION OF COMPOSITIONS

Components which appear in the gas phase alone are referred to as "single phase light" components and those that are present only in the liquid phase are called "single phase heavy" components. In the statement of the following formulas, the flow rates for all of the single phase light components are denoted by $\sum_L v_{j,L}$. For a column with a single feed plate, $\sum_L v_{j,L}$ is equal to the sum of the FX_F's for these components for all of the plates above the feed plate. For all of the plates below the feed plate $v_{j,L} = 0$. The total flow rate of all the single phase heavy components is represented by $\sum_H l_{j,H}$. The separated components are denoted by the subscript "S".

of the separated components which appear both in the expressions for the calculation of the compositions and the convergence procedures are computed by use of the material balance equations outlined previously. The following formulas are developed in a manner analogous to that shown previously, Part 5.

$$y_{ji} = \left(\frac{V_j - \sum_L v_{j,L}}{V_j}\right) \frac{\left(\frac{v_{ji}}{d_i}\right)_{ca} (d_i)_{co}}{\sum_{i \neq H,L} \left(\frac{v_{ji}}{d_i}\right)_{ca} (d_i)_{co}}, \quad i \neq H, L \tag{14a}$$

and

$$x_{ji} = \left(\frac{L_j - \sum_H l_{j,H}}{L_j}\right) \frac{\left(\frac{l_{ji}}{b_i}\right)_{ca} (b_i)_{co}}{\sum_{i \neq H,L} \left(\frac{l_{ji}}{b_i}\right)_{ca} (b_i)_{co}}, \quad i \neq H, L \tag{14b}$$

$$y_{j,L} = \frac{v_{j,L}}{V_j}, \text{ and } x_{j,H} = \frac{l_{j,H}}{L_j} \tag{14c}$$

For separated heavy and light components, the corresponding indeterminate terms of Equations (14a) and (14b) are replaced by their equivalents,

$$\left(\frac{v_{j,s}}{d_s}\right)_{ca} (d_s)_{co} = \frac{1}{\Theta_o}\left(\frac{v_{j,s}}{b_s}\right)_{ca} (b_s)_{co} \tag{14d}$$

$$\left(\frac{l_{j,s}}{b_s}\right)_{ca} (b_s)_{co} = \Theta_o \left(\frac{l_{j,s}}{d_s}\right)_{ca} (d_s)_{co} \tag{14e}$$

respectively, which follow by Equation (19). For a separated heavy, the general formula for $(b_s)_{co}$ is Equation (25).

Unless intercoolers (or heaters) are employed, L_j and V_j are not generally known. Except where they are specified (for example, the specifications of L_o and V_1), the following formulas are recommended for use

$$V_j = \sum_{i \neq H,L} \left(\frac{v_{ji}}{d_i}\right)_{ca} (di)_{co} + \sum_L v_{j,L} \tag{15}$$

$$L_j = \sum_{i \neq H,L} \left(\frac{l_{ji}}{b_i}\right)_{ca} (b_i)_{co} + \sum_H l_{j,H} \tag{16}$$

METHOD OF CONVERGENCE

For a conventional column where a set of specifications such as V_1 and D are made, the following formulas are applicable.

$$(d_i)_{co} = \frac{FX_{Fi}}{1 + \Theta_o \left(\frac{b_i}{d_i}\right)_{ca}}, \quad i \neq H, L \tag{17}$$

The quantity, Θ_o, is the positive root which gives $g_o(\Theta_o) = 0$. The function g_o is defined as follows:

$$g_o(\Theta_o) = \sum_{i \neq H,L.} \frac{FX_{Fi}}{1 + \Theta_o \left(\frac{b_i}{d_i}\right)_{ca}} - \left[D - \sum_L FX_{F,L}\right] \tag{18}$$

It should be noted that for the separated heavy components $d_s = 0$. After $(d_i)_{co}$ has been computed by Equation (17), $(b_i)_{co}$ is calculated in the following manner.

$$(b_i)_{co} = \Theta_o \left(\frac{b_i}{d_i}\right)_{ca} (d_i)_{co}, \quad i \neq H, L \tag{19}$$

In order to illustrate the convergence procedure for complex colums, the equations are stated for a column having two feed plates and two side-streams withdrawn as liquids. Suppose that V_1, D, W_1 and W_2 are specified. The corrected value of d_i is given by

$$(d_i)_{co} = \frac{FX_{Fi}}{1 + \Theta_o \left(\frac{b_i}{d_i}\right)_{ca} + \Theta_1 \left(\frac{w_{1i}}{d_i}\right)_{ca} + \Theta_2 \left(\frac{w_{2i}}{d_i}\right)_{ca}}, \quad i \neq H, L. \tag{20}$$

where Θ_o, Θ_1, and Θ_2 are the positive roots which give $g_o = g_1 = g_2 = 0$, simultaneously. These functions are defined as follows:

$$g_o(\Theta_o, \Theta_1, \Theta_2) = \sum_{i \neq H,L} (d_i)_{co} - \left[D - \sum_L d_L\right] \tag{21}$$

$$g_1(\Theta_o, \Theta_1, \Theta_2 = \sum_{i \neq H,L} \Theta_1 \left(\frac{w_{1i}}{d_i}\right)_{ca} (d_L)_{co} - \left[W_1 - \sum_H w_{1,H}\right] \tag{22}$$

$$g_2(\Theta_o, \Theta_1 \Theta_2) = \sum_{i \neq H,L} \Theta_2 \left(\frac{w_{2i}}{d_i}\right)_{ca} (d_i)_{co} - \left[W_2 - \sum_H w_{2,H}\right] \tag{23}$$

These equations may be solved for the three positive roots, Θ_o, Θ_1 and Θ_2 by the method of Newton-Raphson as described in Part 3.

For the separate heavy components, the indeterminate term in these equations have the following values,

$$(d_s)_{co} = 0, \text{ and}$$

$$(w_{1s})_{co} = \Theta_1 \left(\frac{w_{1s}}{d_s}\right)_{ca} (d_s)_{co} = \frac{FX_{Fs}}{1 + \left(\frac{\Theta_o}{\Theta_1}\right)\left(\frac{b_s}{w_{1s}}\right)_{ca} + \left(\frac{\Theta_2}{\Theta_1}\right)\left(\frac{w_{2s}}{w_{1s}}\right)_{ca}} \tag{24}$$

If the component is separated below the withdrawl ($(w_{1S})_{ca} = 0$, then $(w_{S1})_{co} = 0$. The expression for Θ_2 $(w_{2S}/d_S)_{ca}\, d_S)_{co}$ is obtained by replacing the subscript 1 by the subscript 2 and vice versa in Equation (24). The development of these expressions as well as the following one for $(b_S)_{co}$ (for a separated heavy) is given in part 7.

$$(b_S)_{co} = \Theta_o \left(\frac{b_S}{d_S}\right)_{ca} (d_S)_{co} = \frac{FX_{FS}}{+\left(\frac{\Theta_1}{\Theta_o}\right)\left(\frac{w_{1S}}{b_S}\right)_{ca} + \left(\frac{\Theta_2}{\Theta_o}\right)\left(\frac{w_{2S}}{b_S}\right)_{ca}} \qquad (25)$$

It should be observed in Equation 22 that $\sum_H w_{1,H} = 0$ when W_1 is withdrawn above the feed plate at which the single phase heavy components enter. If W_1 and W_2 are withdrawn from plates p and q below the lowest feed plate, the flow rates of the single phase liquids are computed as follows:

$$\sum_H w_{1,H} = \left(\frac{W_1}{L_p}\right) \sum_H FX_{FH}$$

$$\sum_H w_{2,H} = \frac{W_2}{L_q}\left[\sum_H FX_{FH} - \sum_H w_{1,H}\right]$$

CALCULATION OF BUBBLE AND DEW POINT TEMPERATURES

The bubble point temperature is that value of $T_j > 0$ which gives $f(T_j) = 0$, where

$$f(T_j) = \sum_{i \neq H,L} K_{ji} x_{ji} - \left(1 - \sum_L y_{j,L}\right) \qquad (26)$$

and the dew point is that value of $T_j > 0$ which gives $F(T_j) = 0$, where

$$F(T_j) = \sum_{i \neq H,L} \frac{y_{ji}}{K_{ji}} - \left(1 - \sum_H x_{j,H}\right) \qquad (27)$$

It is to be noted that for a conventional column that for all plates below the feed plate, $\sum_L y_{j,L} = 0$ and that for all plates above the feed plate, $\sum_H x_{j,H} = 0$. For the other plates, the values of the sums are computed by use of Equation (14c).

ENTHALPY BALANCES

Two improvements of the basic calculational procedure given in Part 1 for making enthalpy balances were found. The first of these is the Q-method, described in Part 5. This method makes use of intercoolers (or heaters) as required to maintain the flow rates throughout the column within specified limits. For all problems for which an adiabatic solution was obtained by the method given in Part 1, the Q-method gave the same adiabatic solution. It also gave a solution to those problems for which an adiabatic solution could not be obtained by the procedure of Part 1.

The second improvement consists of another way, called the "constant-composition" method, for the calculation of enthalpies. Use of enthalpies calculated by this method instead of the "conventional method" (Equations (20) and (21) of Part 1) resulted in additional adiabatic solutions for conventional columns. In this method the vapor rising from plate j + 1 of the rectifying section of a column is considered to consist of the distillate and the liquid entering plate j + 1 from plate j. Thus, the total enthalpy, $V_{j+1}H_{j+1}$, of the vapor rising from plate j + 1 may be expressed as follows:

$$V_{j+1}H_{j+1} = \sum_{i=1}^{c} H_{j+1,i} v_{j+1,i} = \sum_{i=1}^{c} H_{j+1,i}(l_{ji} + d_i)$$

or

$$V_{j+1}H_{j+1} = L_j H(x_j)_{j+1} + DH(X_D)_{j+1} \qquad (28)$$

where,

$$H(x_j)_{j+1} = \sum_{i=1}^{c} H_{j+1,i} x_{ji} \text{ and } H(X_D)_{j+1} = \sum_{i=1}^{c} H_{j+1,} X_{Di}$$

The identity given by Equation (28) holds only when convergence is obtained because it is only then that the corrected flow rates of the individual components are in material balance. When the term $V_{j+1}H_{j+1}$ of the enthalpy balances for the rectifying section is replaced by the right hand side of Equation (28), additional adiabatic solutions were obtained. The stripping section is treated in an analogous manner. For adiabatic operation, the balances for a conventional column are as follows:

$$L_j = \frac{D[H_D - H(X_D)_{j+1}] + Q_C}{[H(x_j)_{j+1} - h_j]}, \quad 0 \leqq j \leqq f-2 \qquad (29)$$

$$L_{f-1} = \frac{D[H_D - H(X_D)_f] + Q_C + V_F[H(y_F)_f - H_F]}{H(x_{f-1})_f - h_f]} \qquad (30)$$

$$V_{j+1} = \frac{B[h(X_B)_j - h_B] + Q_R}{[H_{j+1} - h(y_{j+1})_j]}, \quad f \leqq j \leqq N \qquad (31)$$

where,

$$h(y_{j+1})_j = \sum_{i=1}^{c} h_{ji} y_{j+1,i}, \text{ and } h(X_B)_j = \sum_{i=1}^{c} h_{ji} X_{Bi}$$

Other relationships (material balances and an over-all enthalpy balance) needed for the calculation of all the rates are given in Part 1. Enthalpies calculated by use of the constant-composition method may be employed in the Q-method for making enthalpy balances.

The improved convergence tendency of the constant-composition method over the conventional method may be attributed in part to the fact that the former places on the system the additional requirement that each component be in material balance. Also, the constant-composition method gives more stability in calculational process because the denominators of Equations (29) and (31) are always of the order of magnitude of the latent heat of vaporization; whereas, the denominators of the corresponding expressions for the conventional method take on a wide range of values including positive and negative numbers. Instability of the conventional method was most pronounced in systems composed almost entirely of very light and heavy

TABLE 3—Statement of Examples 1 Through 10

Component	COMPOSITION OF FEED, FX_F EXAMPLE No.									
	1	2	3	4	5	6	7	8	9	10
Single Phase Light	....		....		..	....		..	50	....
$C_K^*=_{10}$	....	50.0	....	60.0	..	....	80.00	..	..	....
CH_4	50.0	....	60.0	....	70	80.00	....	85	..	....
C_2H_6	....	....	....	....	..	....	....	..	..	0.54
C_3H_8	....	....	....	....	..	....	....	..	3	28.03
iC_4	....	....	....	....	..	....	....	..	10	15.40
nC_4	33.4	33.4	26.7	26.7	20	13.34	13.34	10	15	7.52
iC_5	16.6	16.6	13.3	13.3	10	6.66	6.66	5	7	20.24
nC_5	....	....	....	....	..	....	....	..	5	11.80
nC_6	....	....	....	....	..	....	....	..	10	4.82
nC_8	....	....	....	....	..	....	....	..	..	7.20
500	....	....	....	....	..	....	....	..	..	4.45

* A fictitious component that has a K = 10 at all temperatures at a pressure of 300 psia.

components. For such systems the denominators of the expressions for L_{j-1} and V_j (Equations (22) and (23) of Part 1) are extremely sensitive to small changes in composition and temperature because H_j is approximately equal to h_{j-1}. The constant-composition method virtually eliminates this problem.

ILLUSTRATIVE EXAMPLES

In the previous investigation of the combinations of the θ-method and either bubble points or dew points (as discussed in Part 5), it was found that bubble points give satisfactory results for all systems except those containing a large percentage of very light components while dew points give good results for all systems except those containing a large percentage of relatively heavy components. For systems composed almost entirely of lights, bubble points tended to give an overcorrection and for systems consisting mostly of heavies, dew points tended to lead to a slow rate of convergence.

As discussed in Part 5, these results may be attributed to the decrease of the slope K versus T with molecular weight which is exhibited by hydrocarbons. Since it is perhaps easier to dampen than it is to speed up a convergence procedure, the possibility of the use of the θ-method and bubble points for all systems was investigated. (The possibility of using direct iteration was ruled out because it is shown in a subsequent paper that this method does not always converge for systems which have a feed plate located at an intermediate position between the top and the bottom of a column.)

Examples 1 through 8 (Tables 3 and 4) show that bubble points may be used for systems consisting of very light components provided additional restrictions are placed on the variation of the temperature profiles between successive trials as indicated in Table 5. The results obtained for Example 7 were not stated in Table 5 because the value of D was not within the specific limits at the end of twelve trails when the change in the temperature profiles were restricted in the same manner as shown for Example 8. It should be mentioned that for these problems, solutions were obtained by use of dew points (with no restrictions other than the averaging of the temperature profiles) in about the same number of trials as shown for bubble points.

The formulas presented for the treatment of single phase as well as separated components were investigated for conventional columns and found to give satisfactory results. The treatment of single phase components is illustrated by Example 9 (stated in Tables 3 and 4). In Table 6, the solution of this example is given. The proposed treatment of separated components is illustrated by the solution of Example 10 (Tables 3, 4 and 7).

TABLE 4—Specifications for Examples 1 Through 10

Example	Specifications
1, 2, 3, 4, 5, 6, 7, 8	N = 18, f = 17, V_1 = 108, D = 90 (vapor), partial condenser, and the feed enters as a vapor at its dew point at the column pressure of 300 psia. Vapor and liquid rates are as follows: in the rectifying section, V = 108 and L = 18; in the stripping section, V = 8 and L = 18. Equilibrium data taken from Part II.
9	N = 10, f = 4, V_1 = 225, D = 75 (vapor), partial condenser, and the feed enters partially vaporized at 140°F at the column pressure of 300 psia. Enthalpy and equilibrium data taken from Part II. The enthalpy of the single-phase light component was taken equal to that of methane.
10	N = 38, f = 19, V_1 = 140, D = 40 (vapor), partial condenser, and the feed ent rs partially vaporized at 240°F at th column pressure of 300 psia. Equilibrium data taken from Part II. Enthalpy data taken from Parts II and V. For the 500-component at 300 psia, $K^{1/3} = 3.3123291 \times 10^{-2} + 1.6652384 \times 10^{-4} T + 2.4310911 \times 10^{-7} T^2 + 6.4148982 \times 10^{-11} T^3$, (T°R). Initial temperature profile was taken to be linear with plate number between 140 and 335°F. Initial vapor rates were 140 and 130 in the rectifying and stripping sections respectively.

EQUATION PROOFS

Proof that Equations (1) and (3) Give Equivalent Sets of Vapor and Liquid Flow Rates. In order to prove that for a given set of L/V's and K's, Equations (1) and (3) give the same sets of flow rates, it will be shown first that for all of the expressions for b_i/d_i, Equations (2), (4) and (5), are equivalent. The equivalence of Equations (4) and (5) is shown by deriving Equation (5) from (4). First, it is to be noted that $l_{f-1,1}/d_1$ may be expressed in an equivalent manner by use of the series obtained by continued application of Equation (1), namely

$$\frac{l_{f-1,1}}{d_1} = A_{f-1,1} \cdots A_{01} + A_{f-1,1} \cdots A_{11} + \cdots + A_{f-1,1} \tag{32}$$

TABLE 5—Results of Θ-Method and Bubble Points for Feeds Containing Large Percentages of Light Components

Example	CH_4 in Feed (FX_F)	C_E = 10 in Feed (FX_F)	NUMBER OF TRIALS $\left\|\frac{\Delta D}{D}\right\| \leq 0.01$	NUMBER OF TRIALS $\left\|\frac{\Delta D}{D}\right\| \leq 0.001$	Restriction of Temp. Profile μ*
1.....	50	..	5	7	½
2.....	..	50	5	7	½
3.....	60	..	6	9	½
4.....	..	60	8	11	½
5.....	70	..	5	6	¼
6.....	80	..	3	5	¼
8.....	85	..	7	10	⅛

* Defined by: T (Assumed for next trial) = T (Assumed for previous trial) + μ [T (Calculated) —T (Assumed for previous trial)].

TABLE 6—Solution of Example 9 Which Contained a Single-Phase Light Component

	TEMPERATURES AND VAPOR RATES						FINAL FLOW RATES (Trial No. 12)		
	Temp. °F Trial No.			Vapor Rates Trial No.			Component	d	b
Plate No.	Initial Profile	6	12	Initial Profile	6	12	Single-Phase Light	50.000	0
0	160	116.33	116.32	75	75.0	75.0	C_3H_8	2.999	9.880×10^{-4}
1	175	199.41	199.68	225	225.0	225.0	iC_4	9.717	2.835×10^{-1}
2	190	207.52	210.09	225	294.6	288.3	nC_4	12.210	2.790
3	205	211.69	214.34	225	294.6	295.5	iC_5	6.335×10^{-2}	6.937
4	220	217.50	219.54	225	294.6	292.4	nC_5	1.059×10^{-2}	4.989
5	235	253.31	252.46	175	204.8	210.9	nC_6	5.750×10^{-6}	9.99994
6	250	260.30	259.56	175	235.5	237.4			
7	265	269.63	269.01	175	233.0	232.9			
8	280	282.07	281.74	175	223.6	226.5			
9	295	298.57	298.47	175	217.6	219.0			
10	310	319.72	319.72	175	211.2	211.0			
11	325	335.14	335.18	175	203.2	204.8			
D (Calculated)		74.961	74.999						
θ_0		0.9852	0.9998						

TABLE 7—Solution of Example 10 Illustrates Separated Components

	TEMPERATURES, VAPOR RATES AND MOLE FRACTIONS (y) OF nC8 AND THE 500-COMPONENT						
	Temp., °F (Trial No. 10)	Vapor Rates (Trial No. 10)	Compositions (y) (Trial No. 10) Component		FINAL FLOW RATES (Trial No. 10)		
Plate No.	10	10	nC8	500-Comp.	Component	d	b
0	165.1	40.0	0*	0*	C_3H_8	54.00×10^{-2}	31.75×10^{-13}
1	175.6	140.0	1.08×10^{-31}	0	C_3H_8	28.03	46.36×10^{-5}
2	182.8	139.2	5.01×10^{-30}	0	iC_4	10.91	44.93×10^{-1}
10	195.6	138.7	8.69×10^{-18}	0	nC_4	52.30×10^{-2}	69.97×10^{-1}
18	208.2	132.6	4.75×10^{-6}	1.13×10^{-10}	iC_5	10.73×10^{-7}	20.24
19	216 8	128.4	1.13×10^{-4}	8.14×10^{-8}	nC_5	14.47×10^{-9}	11.80
20	237.0	109.1	2.05×10^{-3}	4.38×10^{-5}	nC_6	69.86×10^{-13}	48.20×10^{-1}
21	243.8	111.8	2.24×10^{-3}	4.87×10^{-5}	nC_8	0	72.00×10^{-1}
22	249.2	116.0	2.39×10^{-3}	5.27×10^{-5}	500	0	44.50×10^{-1}
30	262.7	128.0	2.80×10^{-3}	6.42×10^{-5}			
37	288.3	126.9	4.22×10^{-3}	1.01×10^{-4}			
38	301.6	125.7	6.29×10^{-3}	1.34×10^{-4}			
39	335.6	115.2	2.03×10^{-2}	6.47×10^{-4}			
D (Calculated)	39.999						
θ_0	0.9998						

* A heavy component was taken to be separated when $v_{ji}/d_i > 10^{30}$

Division of the numerator and denominator of Equation (4) by ϕ_i gives an expression containing the ratio Φ_i/ϕ_i which may be expressed in terms of the A_{ji}'s as follows:

$$\frac{\Phi_i}{\phi_i} = A_{f-1,i} + A_{f-2,i}\,A_{f-1,i} + \ldots + A_{oi} \ldots A_{f-1,i}$$

Upon comparison of this expression with Equation (32), it is seen that

$$\frac{\Phi_i}{\phi_i} \equiv \frac{l_{f-1,i}}{d_i} \qquad (33)$$

When Φ_i/ϕ_i in Equation (4) is replaced by its equivalent as given by Equation (33), the desired result, Equation (5), is obtained.

In proving the equivalence of Equations (2) and (5), it is to be noted that the following formula for v_{fi}/b_i is obtained by successive applications of Equation (3).

$$\frac{v_{fi}}{b_i} = S_{fi} \ldots S_{N+1,i} + S_{fi} \ldots S_{Ni} + \ldots + S_{fi} \qquad (34)$$

Division of the numerator and denominator of Equation (2) by ω_i gives an expression that contains the ratio Ω_i/ω_i. This ratio may be expressed in terms of the S_{ji}'s as follows:

$$\frac{\Omega_i}{\omega_i} = S_{fi} \ldots S_{N+1,i} + S_{fi} \ldots S_{Ni} + S_{fi} \qquad (35)$$

Comparison of Equations (34) and (35) shows that the right hand sides are equal. Thus, substitution of v_{fi}/b_i for the ratio in the expression obtained by division yields the desired result, Equation (5).

When calculations are made from the top of the column down to a particular plate located n plates below the top and k plates above the feed plate, the following expression is obtained by successive applications of Equation (1).

$$\frac{v_{ni}}{d_i} = A_{n-1,i} \ldots A_{oi} + A_{n-1,i} \ldots A_{1i} + \ldots + A_{n-1,i} + 1 \qquad (36)$$

It is to be shown that this same result is obtained by making calculations from the bottom of the column to plate n as indicated by Equation (3). As shown in Part 1, repeated application of Equation (3) gives

$$\frac{l_{f-k,1}}{b_1} = (S_{f-k+1,1} \cdots S_{f-1,1}) \left[\frac{v_{f1}}{b_1} + \frac{v_{F1}}{FX_{F1}} - \frac{l_{F1}}{FX_{F1}} \left(\frac{d_1}{b_1} \right) \right] - [1 + S_{f-k+1,1} + \cdots + S_{f-1,1} \cdots S_{f-2,1}] \left(\frac{d_1}{b_1} \right) \quad (37)$$

where the term $(1 - FX_{F1}/b_1)$ in Equation (3) has been replaced by its equivalent $(-d_1/b_1)$ and the relationship $l_{F1} + v_{F1} = FX_{F1}$ has been used. Multiplication of both sides of Equation (37) by $(S_{f-k,1})(b_1/d_1)$ followed by the elimination of b_1/d_1 on the right hand side of the resulting expression by use of Equation (4) yields

$$\frac{v_{f-k,1}}{d_1} = (S_{f-k,1} \cdots S_{f-1,1}) \left[\frac{\Phi_1}{\phi_1} + \frac{l_{F1}}{FX_{F1}} \right] - (S_{f-k,1} \cdots S_{f-1,1}) \frac{l_{F1}}{FX_{F1}} - (S_{f-k,1} + S_{f-k,1} S_{f-k+1,1} + \cdots + S_{f-k,1} \cdots S_{f-2,1}) \quad (38)$$

Since,

$$(S_{f-k,1} \cdots S_{f-1,1}) \frac{\Phi_1}{\phi_1} = S_{f-k,1} \cdots S_{f-2,1} + S_{f-k,1} \cdots S_{f-3,1} + \cdots + S_{f-k,1} + 1 + A_{n-1,1} + A_{n-1,1} A_{n-2,1} + \cdots + A_{n-1,1} \cdots A_{o1} \quad (39)$$

Equation (38) is seen to reduce to the desired result, Equation (36).

Proof of the Relationship Given by Equation (7). Consider a light component for which $S_{j1} > 1$ for all j. Suppose that in making calculations up from the bottom of the column a j (let it be denoted by m) is found such that $l_{m1}/b_1 \geqq \rho$ (a large number of the order of magnitude of say, 10^{38}). Since it is given that all of the S's are greater than unity

$$\frac{v_{m1}}{b_1} > \frac{l_{m1}}{b_1}$$

Also continued application of Equation (3) gives larger and larger numbers. Thus,

$$\frac{v_{f1}}{b_1} > \frac{v_{m1}}{b_1}$$

Now consider Equation (32). Since it is given that all of the S's are greater than unity, it follows that all of the A_{j1}'s are less than unity. Therefore if the value $A_{j1} = 1$ is substituted in Equation (32) for $j = 0$ through $j = f - 1$, the following result is obtained

$$\frac{l_{f-1,1}}{d_1} < f$$

where f is the number of the feed plate. Also in Equation (5),

$$\frac{l_{F1}}{FX_{F1}} \leqq 1$$

Thus for the component under consideration, the numerator of Equation (5) is less than $f + 1$. Also, the denominator is greater than $\rho + 1$; that is

$$\frac{v_{f1}}{b_1} + \frac{v_{F1}}{FX_{F1}} > \rho + 1$$

Substitution of these results into Equation (5) gives

$$\frac{b_1}{d_1} < \frac{f+1}{\rho+1} \quad (40)$$

Since ρ is so much larger than unity, the inequality obtained by replacing $\rho + 1$ by ρ to give Equation (7) is almost as general as Equation (40).

SYMBOLS USED

(See Parts 1, 2 and 5)

H—Single phase heavy component
L—Single phase light component
S—Separated component

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LITERATURE CITED

(See parts 1 through 5)

Key Words for Indexing

Absorbers
Boiling Points
Columns (Process)
Composition
Computations
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Distillation
Enthalpy
Errors
Separation

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C. D. Holland's biography appeared in PR, September 1961, p. 248

Catalog Helps Cut Warehouse Stocks

Plants and departments exchange surplus material through catalog of common stocks

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Stock control is the never ending process of maintaining a proper balance between inventory and plant operations. Stock records are naturally the basis of any system whether it is the normal card-posting method with minimum and maximum stock points, or the increasingly popular electronic data processing system.

A search for the causes of material problems will reveal several offenders. Some of the more important are:

- Surplus materials from overstocking
- Dead stock and obsolete junk
- Excess stock of insurance items
- Lack of interchangeability information
- Lack of warehouse coordination
- Waste from leakage, damaged, or pilfered items

Materials Catalog. In approaching a solution to these problems, Phillips Petroleum Company did something which, to our knowledge, is unique within the petroleum industry. We inaugurated an all-inclusive, company-wide Materials Catalog. The purpose of undertaking such a voluminous project was to save money by providing all phases of our operations with a method of common item identification. Once systematic identification is made, it is obviously only a short step to adapt to electronic tabulation of items by category and location. Where before various warehouses and different departments had their own stock numbering systems, now all warehouses have the same stock number on all identical items. The need for this program is easily illustrated. A check in one of our operating departments showed 81 similar bearings stocked in one district for use by that department only. Examination of these bearings, and consideration of their intended use, showed that 12 bearings would serve the same needs. The reason so many like bearings were on hand was that we had not taken into consideration their interchangeability. In another department, a single plant had 42 similar pump shafts in its warehouse stock. They carried one shaft for each pump in service within their plant. An analysis of the pump shafts showed that only six of these were required to meet all operating problems. Even closer to home, we found one of the local plants had 148 spare boiler tubes on hand. In checking, no one was able to remember how long they had been stored but indications were that the tubes had been in stock for over 15 years, none of which had been used for several years. At another plant, a package of rotor blades was found still containing the packing slip. Examination showed that these blades had been shipped in care of a superintendent who had been gone from the plant since 1945, and that the equipment for which they were purchased had been junked in 1943. Numerous pump parts, including complete rotating elements, were found for which the pump had been moved or junked.

Some of these extreme cases border on comedy—until you realize what they mean in cold cash. Take the instance of the boiler tubes, their cost would have earned several times the initial cost at the very minimum rate of return. Instead, we still have a shed full of tubes of doubtful use. However, through the identification of common parts by means of cataloguing, many surplus materials are being worked off between the various plants, areas, and departments.

Surplus Material. A common fault of stock control is not to be alerted or aware of your surplus. The sooner an excess is recognized, the better the chance of turning it. Usually by acting quickly, overages can be returned to the supplier for full credit or at least less a handling charge. It is much better to do this than say, "Well, we may need this one of these days," then let it lie around in a bin for a few years to finally be junked. When dead stock does accumulate either from surplus, obsolescence, or just plain junk, rid your stock of it. This can be done by circulating surplus lists within your own company contacting other companies and dealers, or, as a last resort, calling your scrap buyer. A small return is better than none.

Safety Stock. How much money you afford to tie up in safety stock depends on how critical is the operation. Only by weighing the cost of keeping insurance items against product loss from downtime can a decision be made on the economics of keeping safety stock items. Obviously, if the plant has a large percentage of installed standby equipment, the warehouse stock can be held to a lower level. Conversely, a minimum plant requires a different quantity of spares. Only inspection of your individual circumstances will dictate the correct answer. Here then, the warehouseman's knowledge of interchangeability pays high dividends. As pointed out in our experience with bearings, some drastic reductions can be made in most stocks through interchangeability of parts. Knowing different manufacturer's coding numbers provides a ready tool for whittling on the stock level log. Savings can also be made on everyday costs by simply comparing manufacturer's prices for interchangable items.

Adapted from a paper "Warehousing and Inventory Control," presented to the NGAA, Odessa, Texas, May 12, 1961.

Key Words for Indexing

Warehousing	Parts
Materials	Spares
Stores	Catalogs
Inventories	Stocks

# #

New Methods Give HIGH Temperatures

Here's a review of what's being done with shock tubes, magnetohydrodynamics, plasma jets, and electromagnetic principles for generating ultra high temperatures and studying their effects on chemical reactions

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Temperatures ranging from those currently used up to ultra high temperatures of 1,000,000° are being attained and used by recently developed techniques. While interesting scientific and engineering developments in themselves, some are already contributing to everyday technology through research results. Others may, in years to come, affect the hydrocarbon processing industry as a whole by changing the economics of power generation. The aim of this article is to outline the nature of some of these new techniques, their capabilities and limitations, and their potential for the future.

SHOCK TUBE

As is the case with so many developments which are thought of as new, the history of the shock tube goes back quite far—to 1899—but in the 1950s the number of laboratories making use of them has increased from a handful to a hundred or more. They are being used for many purposes, including the study of chemical kinetics, PVT data and rates of energy equilibration among the degrees of freedom of gases, and the study of gas dynamics at high speeds, in which the shock tubes serve as high velocity wind tunnels. Though specialized forms have been developed for these different purposes, all depend on the same principles of operation.

A sketch of a typical shock tube which we use for chemical kinetic studies is shown in Figure 1. In it a sample of gas can be heated at a rate of millions of degrees per second, held at high temperature for up to 20 milliseconds, then cooled at a rate of several hundred thousand degrees per second, and this is done without contact of the gas with a hot tube wall (which could be catalytic), and without using radiation (which could excite or activate the gas), as with photolysis techniques. Thus the shock tube is useful for studying very rapid gaseous reactions, such as those that occur in high temperature cracking or combustion processes.

Example. The operation of a shock tube can be described most clearly by an example. For this, the tube sketched in Figure 1 will be used. The sample and driver sections are pieces of 3 inch stainless steel pipe, 12 feet and 28 feet long, respectively, while the surge tank is 3 feet in diameter and 8 feet long. Thin metal or plastic sheet diaphragms separate the sections, and "O" ring seals are used throughout, so the three sections can be independently evacuated or pressurized.

In a typical experiment, all sections are first evacuated, and the surge tank is left under vacuum. A high pressure (100 psia) of helium is put into the driver section, and a low pressure (2 psia) of the sample gas, which is to be heated, into the sample section. The thin diaphragms separating the sections are chosen so they will not hold much more than the working pressure. When the sharp-pointed plungers (g and h) are pushed in and pierce the diaphragms, the latter rupture suddenly into small pieces.

When the diaphragm between the driver and sample sections is broken, the tube has 100 psia gas pressure in one end, and 2 psia in the other, with nothing separating the two gases. What follows is the interesting phenomenon called a shock wave, whose nature can best be shown by a series of diagrams (Figure 2). In these, pressure is plotted versus distance along the shock tube, at a series of times which are typical of shock tube operation.

Figure 2a shows the original driver and sample gas pressures, just before the diaphragm is punctured. After 0.002 second (Figure 2b), the shock wave (sudden jump in pressure in the sample gas) is well developed and is propagating down the tube at a speed of about 2700 feet per second. To the left of the shock wave is a region of constant pressure which includes not only the part of the sample which has been "shocked," but also some of the driver gas which has expanded. This gas is moving to the right with a uniform velocity of about 1,700 feet per second. The sample gas is heated by the sudden compression, while the driver gas is cooled by expansion. The dotted line represents the interface between sample and driver, which may be a turbulent zone because of the finite time it takes to break the diaphragm. To the left of the region of uniform pressure, the driver gas is expanding, while still farther to the left the driver gas is at its original pressure, since the expansion wave propagates back into the driver gas at the speed of sound (about 3300 feet per second for helium at room temperature).

In Figure 2c the shock wave has traversed most of the sample gas, heating it and setting it in motion to the right, and by the time of Figure 2d a new shock wave,

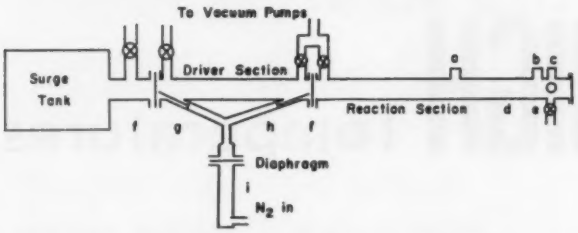

FIGURE 1—In this typical shock tube arrangement, sample of gas can be heated at rate of millions of degrees per second, held there for 20 milliseconds, cooled at several hundred thousand degrees per second, all without heat or cooling sources.

called the "reflected shock wave" has formed. The moving sample gas is being brought to rest by collision with the end plate of the shock tube, and its kinetic energy of motion is changed to heat energy. The gas behind the reflected shock wave is stationary, and at a higher temperature than it was behind the first shock wave. The reflected shock wave passes on into the driver gas, heating it back up to the neighborhood of room temperature (Figure 2e).

When the expansion wave traveling into the driver gas reaches the left end of the driver section, it causes the plunger at that end to rupture that diaphragm (g in Figure 1), and the driver gas begins to expand into the surge tank (Figure 2e). This expansion continues, as shown in Figures 2f and 2g, until the pressure is uniform throughout the tube and tank. Generally, this pressure will be about the same as the original pressure of the sample gas, so the sample is brought back to near room temperature.

Mathematical relationships have been worked out[1] relating these rather peculiar pressure effects to the speed of the shock waves, and to the temperatures produced. For example, if the speed of the first shock wave ("speed of propagation of the high-pressure zone" would be a better description) is known, along with the specific heat of the sample gas, then temperatures and pressures behind both first and reflected shock waves can be calculated. We do this in our shock tube work. The temperature rise for a given pressure rise is substantially higher in a shock compression than in a simple adiabatic compression. For example, if air at room temperature is compressed adiabatically and reversibly from 1 to 10 atmospheres, the temperature rises to about 300° C, while in an irreversible shock compression to 10 atmospheres, the temperature rises to about 500° C.

The temperatures obtained in the shock tube depend on the driver and sample gases, and on the driver/sample pressure ratio. High temperatures are favored by low molecular weight, high specific heat and high initial temperature of the driver gas, high molecular weight and low specific heat of the sample gas, and high pressure ratio. However, it has been found[2, 3, 4] that with low initial sample gas pressures, high driver/sample pressure ratios, and sample gases with high specific heats, the temperature, pressure and velocity of the shocked gas cannot be calculated accurately by the standard equations. Therefore, in most shock tube research involving molecules with high specific heats (such as hydrocarbons), it has been necessary to dilute the hydrocarbon gas with a monatomic gas, usually argon. This reduces the average specific heat of the sample gas, and, in the case of the lighter hydrocarbons, increases the average molecular weight, so that driver/sample pressure ratios less than 100 can be used. Although the argon is chemically inert, it can affect kinetics by increasing the rate of energy equilibration among the reacting molecules, and by acting as a third body in recombination reactions.

Measurement. Several kinds of measurement can be made in a shock tube experiment. These include:

(a) *Speed of the shock waves.* In the apparatus of Figure 1, the speed of the first shock wave is obtained by measuring the time for the wave to travel between two piezoelectric transducers, a and b, by means of an electronic timer. As mentioned above, several other quantities can be calculated from this shock speed. Other types of transducers, such as thin film resistance thermometers which detect the high temperature behind the shock wave, or light beams which are deflected by the shock wave, have also been used.

(b) *Pressure behind the shock waves.* This is measured by another pieozelectric transducer, c of Figure 1. The observed values are close to those calculated from the shock speed.

(c) *Chemical analysis of reaction products.* After the

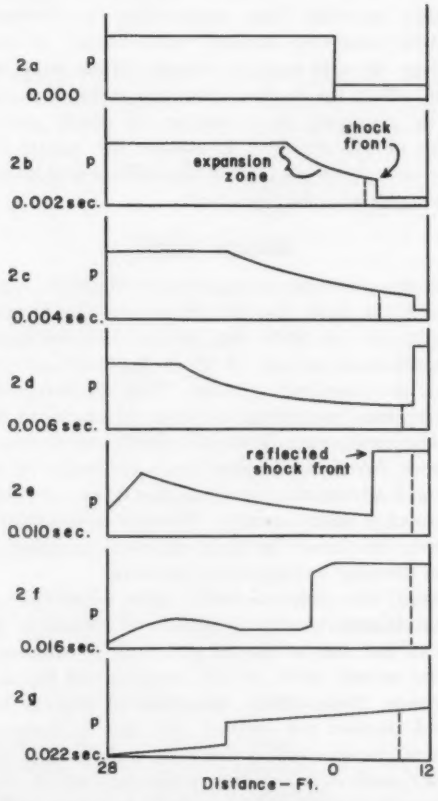

FIGURE 2—These plots show the usual pressure changes experienced in shock tube operation and studies.

run is over, a sample of gas for analysis can be taken from value e, Figure 1.

(d) *Gas densities.* These have been measured by x-ray absorption and found to be close to those calculated from the shock speed.

(e) *Gas temperatures.* These have been measured by spectroscopic methods[5] and shown to agree with calculated values. Usually, gas temperatures are calculated from the shock speed.

(f) *Emission and absorption spectra.* These have been used extensively to observe the appearance and disappearance of molecules and radicals. Reaction rates can be followed behind either the incident or reflected shock waves. If the rates of reaction can be followed completely by spectroscopic methods, so that a sample of product gas need not be obtained, then the surge tank and the second plunger and diaphragm may be dispensed with.

Kinetics. Extensive kinetics information on hydrocarbon pyrolysis has been obtained by shock tube techniques, particularly in the high temperature range corresponding to temperatures in flames. For example, further evidence has been found that pyrolysis of ethane to ethylene is a free radical chain reaction (as had been suggested earlier to explain results obtained at lower temperatures), while it seems clear that pyrolysis of ethylene to acetylene and butadiene at high temperatures is a molecular reaction, not involving free radicals. Experiments on the pyrolysis of oxidizers such as N_2O_4, NO_2, and O_2 have been carried out, as well as several studies on actual combustion reactions, such as H_2-O_2, CH_4-O_2 and H_2-Br_2. Since the present article is concerned with techniques rather than results, the reader is referred to two recent reviews[6, 7] for further details on the chemical kinetic results obtained by the use of shock tubes. There is no doubt that as their principles of operation become more widely understood, and experimental methods are improved, shock tubes will be used to study many more reactions than the number covered so far.

A continuous shock tube reactor has been devised at Cornell Aeronautical Laboratory.[8, 9, 10] This consists of a large number of small shock tubes, closely spaced around the outside of a drum, parallel to its axis. The drum rotates rapidly on its axis, and jets of driver and sample gas are introduced at opposite ends of the tubes. The jets are fixed in space while the drum rotates, so that when one of the tubes moves in front of a jet, the effect is the same as removing the diaphragm in a shock tube. Fixed tubes are also provided for removal of shocked sample gas and used driver gas: the geometry and speed of rotation of the device must be carefully planned to ensure that the shock wave forms at the optimum part of the cycle, and a clean separation of sample and driver gases is achieved. A working model of such a reactor has been built and operated, which produces high-temperature air for aerodynamic testing. So far no application to high temperature processing (such as production of NO by heating air, or of acetylene by pyrolyzing hydrocarbons) has been made.

For aerodynamic studies, shock tube design tends to be quite different from that used for kinetic studies. The idea is to produce a rapidly moving stream of air, at the desired temperature, pressure and velocity, in which a model can be placed. In a typical arrangement, a nozzle is placed at the downstream end of the sample section, so that the air that is compressed, heated and accelerated by the shock wave expands through the nozzle, cooling back to near room temperature, but accelerating to still higher velocity. In order to achieve velocities of 15,000—20,000 miles per hour at reasonably high pressures, very high driver pressures must be used, and the driver section of the shock tube must be capable of holding pressures up to 10,000 psi. Sometimes rich hydrogen-oxygen mixtures are used as driver gas. When these are burned in the driver section, the resulting hot hydrogen-steam mixture is a more powerful driver than room-temperature hydrogen. The disadvantage of this arrangement for aerodynamic studies is the short testing time available—only a few milliseconds. However, with carefully designed instrumentation, such shock tunnels were used to obtain the first laboratory data on heat transfer rates at missile re-entry velocities.

ELECTROMAGNETIC SHOCK TUBE

Shock tubes in which the driver gas is heated by an electric current have been built[11, 12] but their use so far has been limited. Such a tube is illustrated in Figure 3, although several other configurations have been used. When the condenser is discharged through the driver gas, the latter is heated, essentially by resistance heating, to a very high temperature, perhaps as high as one million °F. This, of course, raises the pressure very considerably and the hot, compressed gas is a good shock tube driver. Besides this, interaction between the magnetic fields generated by the current flowing one way (up) in the lead strap and the other way (down) in the gas tends to force the conductors apart. Since the gas is much lighter than the lead strap, it is the one that moves, and the contribution of this effect to the shock speed is comparable to that of the ohmic heating. With hydrogen as both driver gas and sample, shock waves with velocities up to almost 1,000,000 miles per hour have been produced in this kind of device, because of the very high temperatures that can be produced by the discharge, and the augmentation by the magnetic fields.

It has been suggested[13] that such a shock tube could be used for rocket propulsion. Hydrogen would flow through the shock tube in a continuous stream, and periodic electric pulses would drive the hydrogen out of the shock tube open at the downstream end with such a high velocity that the specific impulse would be on the order of 10,000 sec or more. No diaphragm separating driver and sample sections would be used, since the electrical discharge would instantaneously heat up and compress the part of the gas used as driver.

TWO NEW WORDS

When a gas is so hot that it is highly enough ionized to be a fairly good conductor of electricity, it is sometimes called a *plasma.* The temperatures needed to produce substantial conductivity vary from 3000° F. For alkali metal vapors, which have low ionization potentials, to 10-20,000° for gases such as nitrogen with high ionization potentials. The fraction of ionization increases

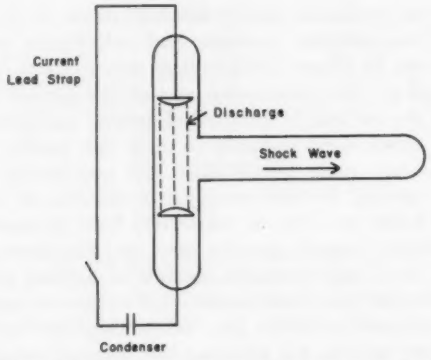

FIGURE 3—In electromagnetic shock tubes, such as this, the driver gas is heated by an electric current discharging across condenser plates.

with increasing temperatures, of course, and at high enough temperatures not only the valence electrons, but inner ones as well, become detached from the nucleus. Sometimes reference is made to a "fully ionized plasma" which consists of electrons and atomic nuclei, in the gaseous state.

The electrically driven shock tube is just one of several recently-developed devices that involve the electrical and magnetic properties of conducting gases. The word "*magnetohydrodynamics*" has been used to describe the study of these properties, and the adjective "magneto-hydrodynamic" to describe devices which involve them. Both noun and adjective are frequently abbreviated to MHD. Although these are long and forbidding words, the devices can be explained in simple language because the same principles that apply to currents flowing in solids apply to those flowing in gases.

PLASMA JET

This device is used to produce a stream of gas as hot as 50,000° F. by passing an electric current through the gas. Such high temperatures, considerably above those obtainable in illuminating or welding arcs, are possible because the design of the apparatus constricts the arc so that a large amount of electrical energy can be put into a small amount of gas.

A sketch of a plasma generator[14, 15, 16] is shown in Figure 4. The gas to be heated enters either tangentially around the wall of the arc chamber, or parallel to it, so a flow of cool entering gas keeps the walls from overheating. The gas is heated by passing through the arc, and leaves through the hole in the ring-shaped anode as a very hot beam of plasma.

In contrast to the shock tube, the plasma jet can operate continuously for minutes. The limiting factor in length of operation is erosion of the electrodes. The plasma temperature can be higher than the melting point of any known electrode materials, and it is only by careful design that the electrodes can be protected. They are usually water cooled, and sometimes made of refractory materials such as tungsten.

Besides these design features, there are two so-called "pinch effects" which constrict the plasma, causing it to move through the center of the hole in the anode and stay away from the anode itself. The first of these effects is due to the rise in gas conductivity with temperature. Since gas enters the jet from the outside, there tends to be a temperature, and hence a conductivity, gradient through the jet, and the current naturally tends to flow through the middle part where the conductivity is the greatest. This leads to further heating of the middle part, and so on, so the arc contracts to a narrow zone down the center of the generator, rather than spreading throughout all of its volume. Second, the magnetic fields generated by different parts of the arc current all flowing in the same direction tend to draw the different parts together, resulting in further constriction of the plasma beam. This is the reverse of the effect occurring in the electromagnetic shock tube, where the magnetic fields due to currents in opposite directions force the conductors apart. Once the plasma has passed through the anode opening, it spreads out because it is no longer carrying an electric current, and these "pinch" effects are not operative. The velocity of the gas as it leaves the generator is moderate, so the largest part of its energy is present as heat rather than as kinetic energy of motion.

Power Supply. The power supply needed to operate a plasma jet has characteristics similar to those used for welding. In fact, a number of commercially available plasma generators do use welding type power supplies. Some quite large units have been built, one of which operates at 2000 KW, and can heat 2000 cfm of argon to 5,000° F., and smaller flow rates to higher temperatures.[17, 18] More commonly, power consumptions of 10 to 100 KW are used. The electrode goemetry need not be just as shown in Figure 4, and the polarity may be reversed, so the plasma leaves through a hole in the anode. The main requirement is suitable gas flow to cool the electrodes and produce a stable arc.

Chemical Synthesis. Plasma jets can be used in chemical synthesis.[19, 20, 21] For example, with nitrogen gas flowing through the arc, powdered titanium can be introduced to the plasma just outside the generator, or even inside it. The titanium vaporizes in the gas stream, but when the jet strikes a cold surface, a deposit of TiN is formed. Coatings of several refractory metals and compounds can be deposited by this technique.

Plasma jets have also been used to synthesize acetylene

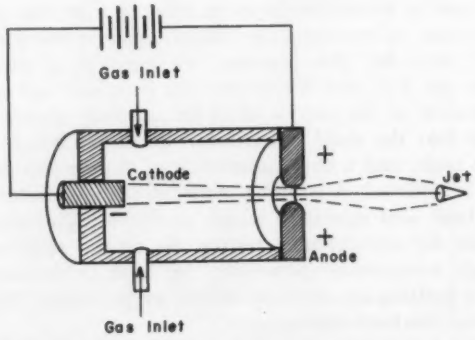

FIGURE 4—This plasma jet device can produce stream of gas as hot as 50,000° F by passing gas through an electric arc.

and cyanogen. This has been carried out by using a graphite anode (Figure 4) and plasmas containing hydrogen and nitrogen respectively. The products were formed by reaction of the plasma with the electrodes. However, a better way to synthesize acetylene was to introduce methane into an argon plasma as it emerged from the generator, then quench the gas mixture on a water-cooled surface. As much as 80 percent of the methane introduced to the jet was converted to acetylene. While this is a very high yield, the economics of producing such low cost chemicals as acetylene by this process are not promising, because of the high cost of equipment and electrical power. However, production of special purpose refractories and coatings by plasma jet methods is likely to become common.

For Testing. Plasma jets are being used to test materials, such as rocket nose cones, that are subjected to aerodynamic heating. Air plasmas can be produced which are similar to the hot, relatively stagnant air that surrounds the front of a rocket as it enters the atmosphere. The air around the nose cone becomes hot because it receives kinetic energy from the rocket. From the rocket's point of view, the air is approaching it at perhaps 15,000 mph, and then the air is brought to rest as it strikes the missile. When the kinetic energy of air moving at 15,000 mph is converted to heat, the resulting air temperature is near 10,000° K. Simulation of aerodynamic heating is not exact because the cooler, rapidly moving air stream farther out from the rocket is lacking, but for comparing the relative performance of different materials, this is a good technique.

MHD POWER GENERATION

When a conductor moves perpendicularly to the direction of a magnetic field, an electrical potential is generated in the conductor, perpendicular to both the direction of motion and the magnetic field direction. The sense of the potential is given by Fleming's right-hand rule, which is as follows: "Place the thumb, index finger, and middle finger of the right hand mutually at right angles. Then if the index finger points in the direction of the magnetic field and the thumb in the direction of motion, the middle finger will point in the direction of the induced emf." If electrodes are placed on the sides of the conductor, power can be withdrawn from the system, and the conductor tends to slow down. In an MHD generator, the conductor is a gas flowing in a duct perpendicular to a magnetic field, and the electrodes are placed on opposite sides of the duct, as shown in Figure 5.

Such generators are being seriously considered for large-scale power production.[17, 18, 22] The gas would be products of a coal or hydrocarbon flame with 0.1 to 1 percent of an alkali metal salt added to make the gas electrically conducting. The magnetic field would be produced by field coils, as in conventional generators, which would be energized by part of the current produced in the generator itself.

As electrical energy is withdrawn from the gas, the temperature and electrical conductivity fall. The point is eventually reached where electrical energy can no longer be withdrawn because of low gas conductivity.

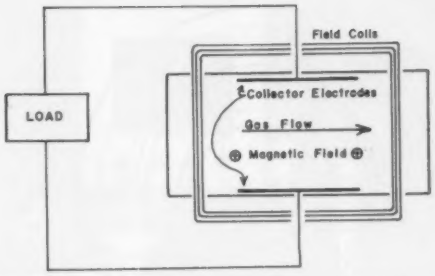

FIGURE 5—In an magnetohydrodynamic (MHD) generator, the conductor is a gas flowing in a duct perpendicular to a magnetic field, and electrodes are placed on opposite sides of duct.

This type of generator is being considered chiefly for large-scale applications because the heat and viscosity losses in a small generator would be too great. Such a generator can very efficiently convert into electricity the energy withdrawn from the gas, estimates of efficiency ranging from 50 to 80 percent. However, the gas temperature is still quite high at the point where the conductivity becomes too low, and if the exhaust gases are discarded the overall efficiency is low. Therefore, it has been suggested that an MHD generator may be a "topping" device, used in conjunction with a conventional steam turbine generating plant. The combustion products from burning coal, for example, would flow first through an MHD generator which would convert about 25 percent of the combustion heat very efficiently into electricity. From the MHD generator the still hot combustion gases would move on to the boiler of a conventional steam plant. The addition of the MHD generator could increase the overall efficiency of the power station from, say 40 to 45 percent.

Numerous problems must be solved before practical MHD generators are built. Some are connected with the gas dynamics—for example, electron motion in the conducting gas can produce an axial as well as a transverse voltage, and it may be necessary to have several short electrodes along each side instead of one long one as shown in Figure 5. The materials problem is also very severe, since the gas in the generator must be very hot (at least 3000° F.) to keep the conductivity high and prevent excessive ohmic losses. Considering the many problems involved, it seems that ten to twenty years will be needed to develop commercial units.

An MHD generator can be operated in reverse[13] as a rocket motor. Such a motor migh consist of a plasma jet whose output would pass into the duct of the "generator." A voltage would be impressed across the electrodes, and current caused to flow through the gas in the opposite direction to that in which it would normally flow. This would accelerate the plasma and it would leave the right end of the duct through a nozzle at very high velocity. As in the case of the MHD shock tube, specific impulses in the range of several thousand are possible.

ZETA AND THE STELLARATOR

Some of the electromagnetic principles mentioned above are involved in the operation of devices now under development to convert energy obtainable by atomic

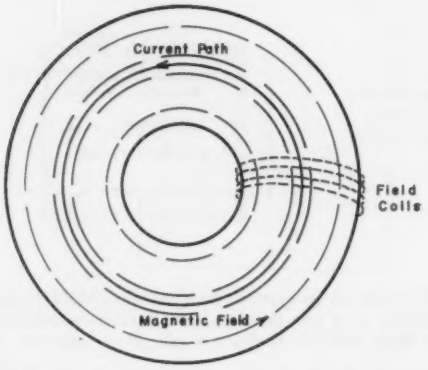

FIGURE 6—In this top view of the ZETA apparatus, as gas at low pressure (10^{-4} mm) is contained in a doughnut-shaped tube, in which a steady axial magnetic field is held by current-carrying coils wound around the tube.

fusion to electrical energy. Atomic fusion reactions will not occur until the elements such as hydrogen or deuterium are heated to about 100,000,000°, so they must be contained and heated in a non-material container.

In the ZETA apparatus[23] a gas at low pressure (10^{-4} mm) is contained in a doughnut-shaped tube, in which a steady axial magnetic field is held by current-carrying coils wound around the tube (Figure 6). The gas in the tube is made slightly conducting by a radio-frequency discharge. The gas is made the one-turn secondary coil of a transformer, the primary being outside the tube, and when a condenser bank is discharged through the primary, a current pulse is generated in the gas, the current path being a circle through the doughnut-shaped tube, parallel to the magnetic field. At the beginning of the current pulse only the electrons move rapidly, since they are accelerated fastest because of their lighter weight compared to the ions, but the electrons collide with the atoms and ions, accelerating them in the same direction as the electron current, and causing further ionization. As in the plasma jet, the magnetic "pinch" effect causes the current path to be constricted. By the end of the condenser discharge the current is all going into an intensely hot ring of gas, much smaller in cross-section than the tube diameter. Within this ring, the pressure is much higher than in the original gas, and the many collisions between the particles lead to an equilibration of energy among the electrons and ions. The axial magnetic field helps to hold the current path steady near the middle of the tube. The condenser discharge time is a few milliseconds, during which the gas is heated to about a million degrees.

In the stellarator,[24, 25, 26] a gas is also heated by making it the secondary coil of a transformer, but instead of using the "pinch" effect to confine the plasma to the center of the tube, the axial magnetic field is made strong enough so it can confine the plasma. This cannot be accomplished in the doughnut-shaped tube of ZETA, but it can be if the tube is twisted into a figure-8 shape. Again, plasma temperatures of about a million degrees have been reached for millisecond times.

These million degree temperatures are too low to start fusion reactions, and plans are to introduce further energy into the gas using pulsed magnetic fields. Once a fusion reaction is started, the hope is that it will be self-sustaining, so that the plasma would become the primary of the transformer, and electrical energy withdrawn. Perhaps the chief problem in the development of this type of generator is stabilizing the position of the plasma. Many refinements have had to be made in both ZETA and stellarator apparatus before the plasma would remain in the desired trajectory for as long as a few milliseconds.

The tremendous potential of the fusion process of energy conversion may be shown by noting that in one of the reactions being considered for this type of process (that of two deuterium atoms to produce one atom of helium of mass 3 and a neutron) the energy released is about a million times as great as is released by the combustion of the same amount of deuterium in air. Somewhat similar reactions can occur with hydrogen but the temperature needed to start them is higher. Since there is an abundant source of fuel for such reactions, and the reaction products are not as hazardous as those from fission reactions, reactions of this type are sure to be important for power generation in the future.

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Key Words for Indexing

Effects/Pinch	Plasma
Electromagnetic	Shocks
Jets/Plasma	Temperature
Kinetics	Tubes/Shock
Magnetohydrodynamics	Waves/Shock

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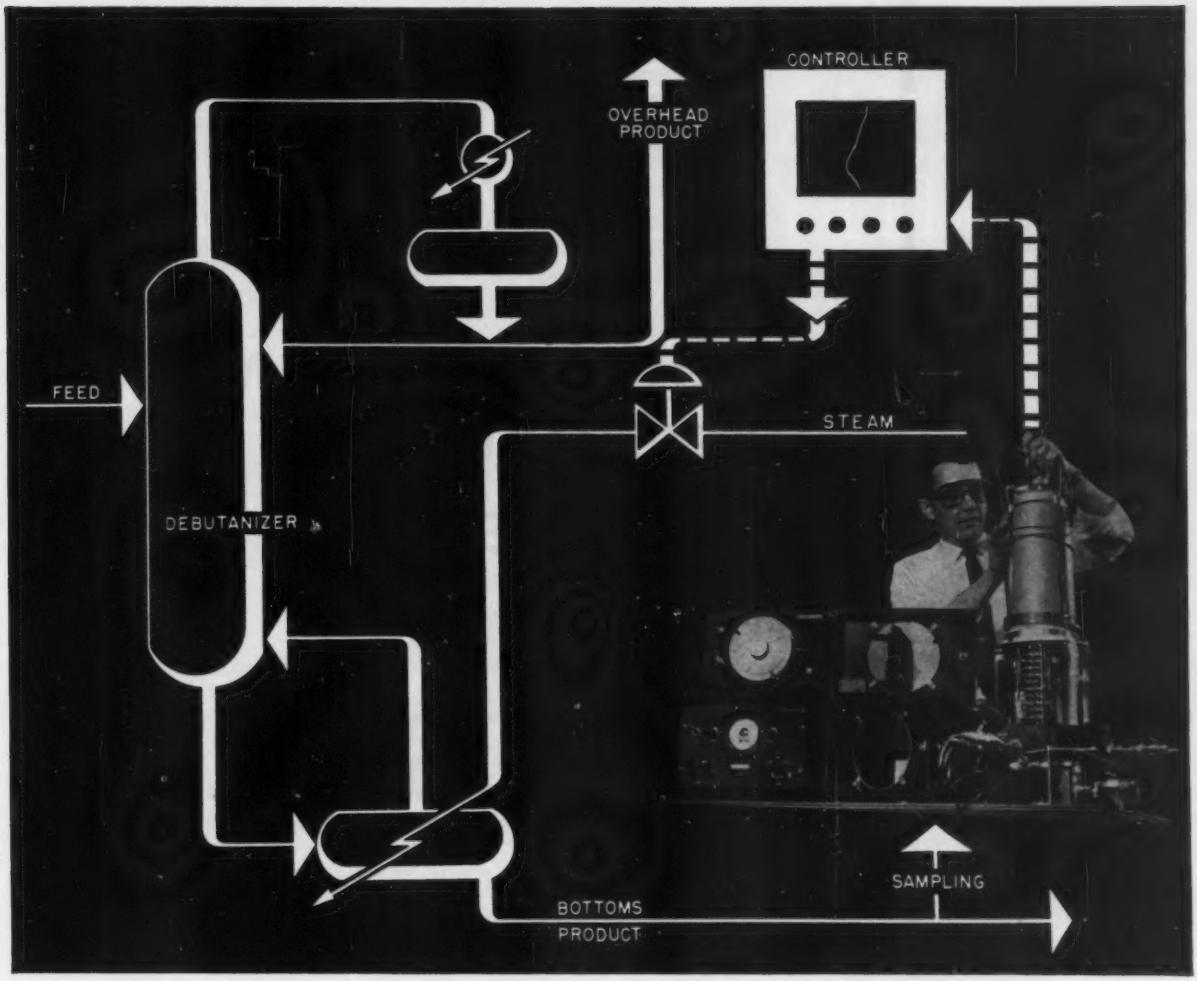
Gordon B. Skinner is a group leader in chemical thermodynamics and kinetics research for Monsanto Research Corp., Dayton, Ohio. He has been working on hydrocarbon pyrolysis and combustion using shock tube techniques. Mr. Skinner, who joined Monsanto Research this year, had been with Monsanto Chemical Co. since 1951. He received his B.S. and M.S. degrees from the University of Manitoba and PhD. degree from Ohio State University.



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PART 1 MANAGEMENT DEVELOPMENT: PAST, PRESENT, FUTURE

A Look at Yesterday's Management Training

Charles H. Vervalin
Hydrocarbon Processing & Petroleum Refiner Staff

What is "management development" and, when and why did it begin? Perhaps the answer to this imposing question reveals the very heart of the American "competitive enterprise" economy—a system that has seen its most dramatic growth during the past 25 years. In this brief span U.S. industry has blossomed into the source from which has developed a society featuring the highest standard of living in the world's history.

The story of management and supervisory development is an integral part of this growth. It is a part that should be fully understood by the young engineer who wants to be a part of the "management team." In fact, in the "management development" story are clues to the emergence of the "professional" manager, his present role in industry, and what it will be tomorrow.

A definition. I would offer, as one definition of management development, the following: Management development is the selection, training, and nurturing of men—to give them the *basic* personal and intellectual qualities required of a manager in modern industry. The goal: to place him in a supervisory or managerial position.

The management training process is one of helping the trainee acquire the qualities of leadership, such as how to handle people, how to make a sound business decision, etc., plus the myriad of "technical" skills involved.

Where did it begin? Obviously, management development, as it is understood within the above definition, has been around for ages—as long as business itself. Management development did not occur spontaneously. It grew and changed with the economy itself. So the real study of supervisory training is a study of *emphasis* and *change* that has taken place through the years in the selection and teaching of managers and prospective managers.

The developing of managers and manager trainees has ranged from the do-it-yourself approach of "coming up through the ranks" by sheer job efficiency and personal magnitude, today's highly sophisticated seminars and personal-development laboratories, such as those conducted at Arden House.

Setting the stage. To put our discussion in perspective, we will look back over the preceeding 25 years to see how and why management development has been handled the way it has. We'll begin arbitrarily at 1935—not because that year has any special significance, but because it is logical to begin at a time when the dawn of today's industrial America was moving into daybreak.

In 1935, America was slowly lifting herself from an agonizing depression. She had experienced an era of dynamic industrial expansion that saw the birth of flight and mass motorized transportation, among other things. She had seen the peak of the purely "capitalistic" economy characterized by the giants and tycoons of industry—the Rockefellers, Fords, and Carnegies.

The period around 1935 was the beginning of the end for the huge family controlled company, and an unorganized labor force. Vigorous enforcement of anti-trust laws, wider distribution of corporate stock among the population, and a labor force growing in influence and power was the beginning of a new era in industry.

Depression-period managers. In the period of recovery from the great depression, American business made a careful reappraisal of itself. This was a period of reform—of close, introspective self evaluation. Business leaders were beginning to recognize that the day of the one-man, autocratic type of management leadership was on its way out. But until 1941, little was done toward specific training programs for management prospects. The sophisticated social-science approach to management development was still a thing of the future, with its emphasis on "human relations," "sensitivity programs," college-campus management seminars, and the like.

The post-depression, pre-war manager trainee was a hodgepodge of the old and the new. He was caught up in a period of remarkable transition in business philosophy that featured both the old "let the strong and dynamic rise to the top" idea of the past, and the so-called "human relations" approach to developing managers—still on the horizon, but coming closer.

The leaders of industry in this transition period would not have known what a "professional" manager is. No doubt, they would have viewed the *planned developing*

"Human relations" approach to management training has been featured in past 10-15 years—tailored to the new "democratic" type of company.

of managers with wide-eyed wonder, and perhaps skepticism. The idea that "managers are born and not made" was still etched deeply in memory if not in fact. Enough of the "old school" industrial leaders survived the depression to fortify this view, which would now be classified as a little cynical—even ignorant.

The old school! These "old schoolers" for the most part supported the "scientific management" approach, popular from about 1910-35. Organizations were viewed as a *machine* that functioned without people—purely authoritarian and autocratic. This structure was supported by the German sociologist, Max Weber. His military experience and observations of German industry convinced him that business enterprise was purely structural and mechanical, and that people were frail and unreliable.

An American engineer, Frederick W. Taylor, also influential in this old-school position, emphasized the status hierarchy, and impersonal calculations and measurements as a key to sound management. It is clear then, from this position, that there was little attempt or desire to formally develop the qualities of *people* as prospective leaders. If a man was industrious and clever enough to become a manager—good enough. If not, that was his tough luck. The big, impersonal machine known as the company came first.

The war and change. It has been said that evil sometimes serves as the catalyst for good. If this is true philosophically, it is also true practically. Such is the case with World War II and its affect on American industrial and intellectual growth.

With the beginning of war, the United States was suddenly transformed from a post-depression nation struggling for growth, to a country faced with the need for rapid, full scale industrialization. To complicate matters was a labor force depleted by men called to military service. What had before been a problem of slow growth and few jobs, suddenly became a problem of many jobs and *how to grow fast enough.*

In this period, the management ranks, too, began to feel the pinch of wartime manpower demands. It was during these critical war years that many men moved into management and supervisory positions who would otherwise have been bypassed. Under the "do or die" pressures of war, and its attending patriotism, many of these men did outstanding jobs. Still others—square pegs forced into round holes—failed miserably. It was this latter group that crystallized, for upper management, the need to prepare men for management duties *before* promotion, or at least while they were at the lower echelon of management (foremen, first-line supervisors, etc.).

To further focus attention on the need for formal management training, was the image of the post-war future. The vast conversion of a wartime economy into a peacetime one was just ahead. In prospect was an enormous need for consumer items, and the training of ex-servicemen flowing back into a booming, dynamic, highly industrialized society. It was at this point, in the early 1940s, that formal "management development" as we now know it, began to take shape. The failures and needs of management, accentuated by wartime demands on its creativity and leadership, opened the door to planned, organized management training programs.

The transition period. The war brought on almost overnight change in American industry. In the future lay growth, growth, and more growth. Technological progress made during the war carried over into peacetime industry, with its consumer-item competition.

It was in this immediate post-war period, in the late '40s and early '50s that the engineer made his debut as a part of management. The increasing emphasis on technology now reversed what had been a trend in business relegating the engineer to a strictly utilitarian position. He was formerly recognized as a mechanistic necessity, and his prospects as a member of management were vague and ill defined. His traditional preoccupation with *material* and *things* instead of *people* and *economics* made him a poor prospect as a leader, under the pre-war setup.

Now the tables had turned. The engineer in post-war America was emerging in a dominant role in business. Business needed and demanded more of him. As his role became increasingly interwoven with the over-all complexity of industry, he began to blend into the "big picture" of management.

The engineer as a manager. As the need grew for more and more engineers in decision-making jobs, one factor stood out that was to become one of the underlying reasons behind post-war methods and trends in management. development. That factor was this: The engineer, while a creative genius when working with *things* and *materials* was weak in some of the qualities most highly valued in prospective managers and supervisors.

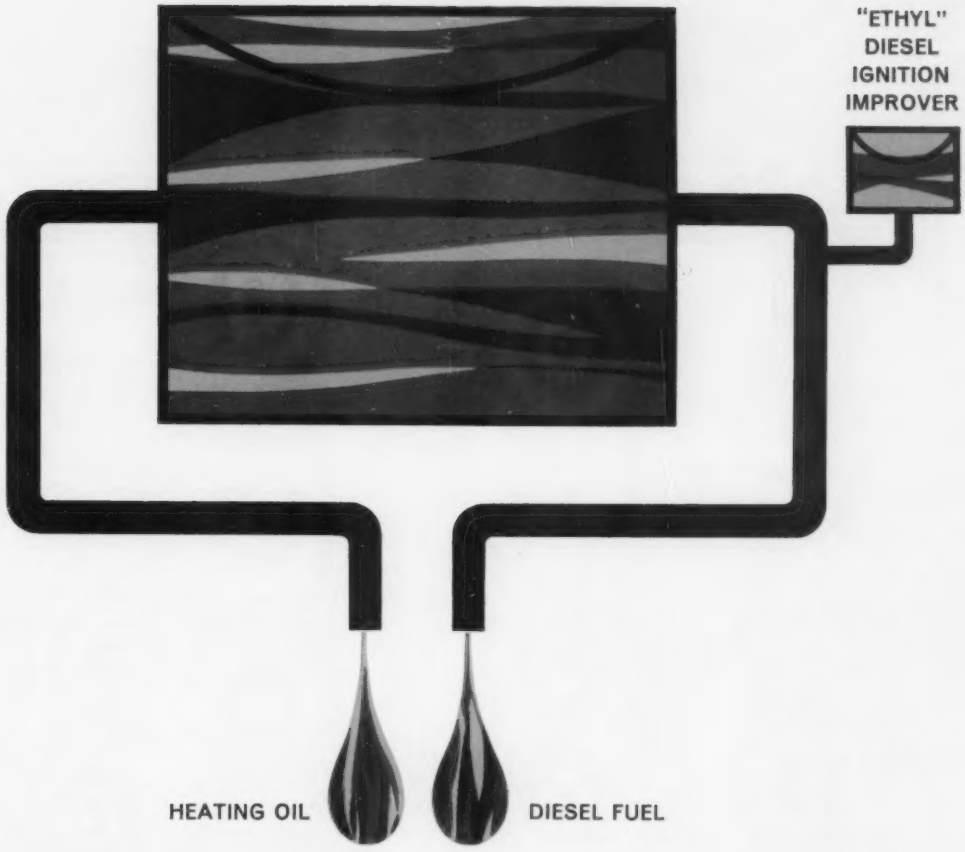
Some of the things he was missing included: (1) lack of a sense of communications, both written and oral, (2) lack of a feeling for how to deal with people and promote group harmony, (3) a tendency to be preoccupied with his own specialized field of interest, instead of seeing industrial and business problems as a *whole,* (4) little or no interest in the social sciences and economics.

This is only a partial list of some of the more important areas, and obviously does not pertain to *all* engineers in *all* situations. But generally, I think it is a fair analysis of the engineer of 1945, and in many cases the engineer of today.

Thus, the old-school proponents of scientific management were precisely correct in their view of the engineer as a utilitarian necessity rather than as a prospective leader. But the changing economic and social climate demanded his service as a leader. The need for technological know-how was becoming an important requisite in managers and supervisors.

Top-level management then, in the late '40s and early '50s, began to take increasing interest in the engineer as a management prospect. The result was that many early

TWO FROM THE SAME TANK



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management development programs were oriented to his needs.

These programs had their roots in the theories of leadership set out by various behavioral scientists. They dealt with what seemed to be two key problem areas in a man's transition from follower to leader, or manager. These were "human relations" and "communications."

Human relations. The "human relations" school of management development focuses its attention on making the prospective manager, or manager-in-training, aware of his subordinate's needs, with emphasis on (1) recognition as an individual, (2) pride in work, (3) fair treatment, (4) a real chance to be heard, and (5) a sense of belonging within the company and work group.

Human relations emphasis in management training thrived from about 1938 to the mid-1950s. It began slowly at first, and gaining momentum during and immediately after the war. In this period there was a complete about-face from the "scientific" approach previously discussed.

The human relations approach regards people as if they existed without organizations. Why the change? Along with the socio-economic revolution brought on by the war and its exploding economy, came an acute awareness by management of man's needs as they relate to his job.

Human relations was emphasized in 1930 in the book *Management and the Worker,* by Fritz Roethlisberger and W. J. Dickson. These men were 15 to 20 years before their time. It took a war and dramatic social change (which featured rapid changes in technology and higher education) to put their theory into practice.

Now business organization was viewed, not as a mechanistic intangible, but rather in terms of human values. There developed a growing awareness of feelings, beliefs, ideas, perceptions, attitudes and sentiments.

The "happy" worker. Management was beginning to take seriously the organization chart's human aspects. The basic assumption was that man could be induced to work more productively when his social and psychological needs were fulfilled. This organizational "new look" was naturally more complicated than the mechanistic approach, because human behavior, being intangible and variable, is harder to deal with.

Neverthless, training programs and industrial relations became oriented to a nomenclature something like this: (1) the need for group and personal affiliation is important in business, (2) people are best motivated by group decision making and democratic participation, (3) positive feeling and *liking* are fundamentals in group action, (4) people need understanding, empathy, and self-realization.

We could not possibly treat in this short article the many and varying management development programs that sprung from the early "human relations" fountainhead. It suffices to say that many of them failed—probably because of the subtle and delicate task of influencing—even remolding—human nature. The goal was a sort of Utopian organization built on perfect group harmony. Anyone even remotely familiar with the complexity of human psychology can readily see what a Gargantuan task this would be. Yet, it was tried, sometimes successfully—sometimes not.

Communications. If it is true that the "human relations" approach has dominated management training for the past 15 years, it is equally true that one of its integral parts, communications, has played a leading role.

With the passing of the autocratic system of management, and increasing group decision making, previously non-existent problems in communications arose. No longer was it a simple matter of the "boss" handing down mandatory ultimatums. The company had grown too big for that. Important decisions were being made at the departmental level. Decentralization was taking place throughout the organization, and increasing technology was bringing the engineer more and more into the decision-making scheme.

The communications problem has been attacked in a deluge of literature and training programs on all aspects of the subject—how to speak effectively, how to listen, how to write a technical report, how to read faster. This struggle with words and ideas has often been the target in "As Management Sees It," in which this article appears.

The reason, then, for emphasis on communications should be clear. Management, under the liberalized company setup of the '50s, had to communicate, and communicate well. Yet, the growing complexity of business and group relations seemed to continue making communications increasingly difficult. Thus, management development programs through the '50s were seen waging a continuous war against communications failure.

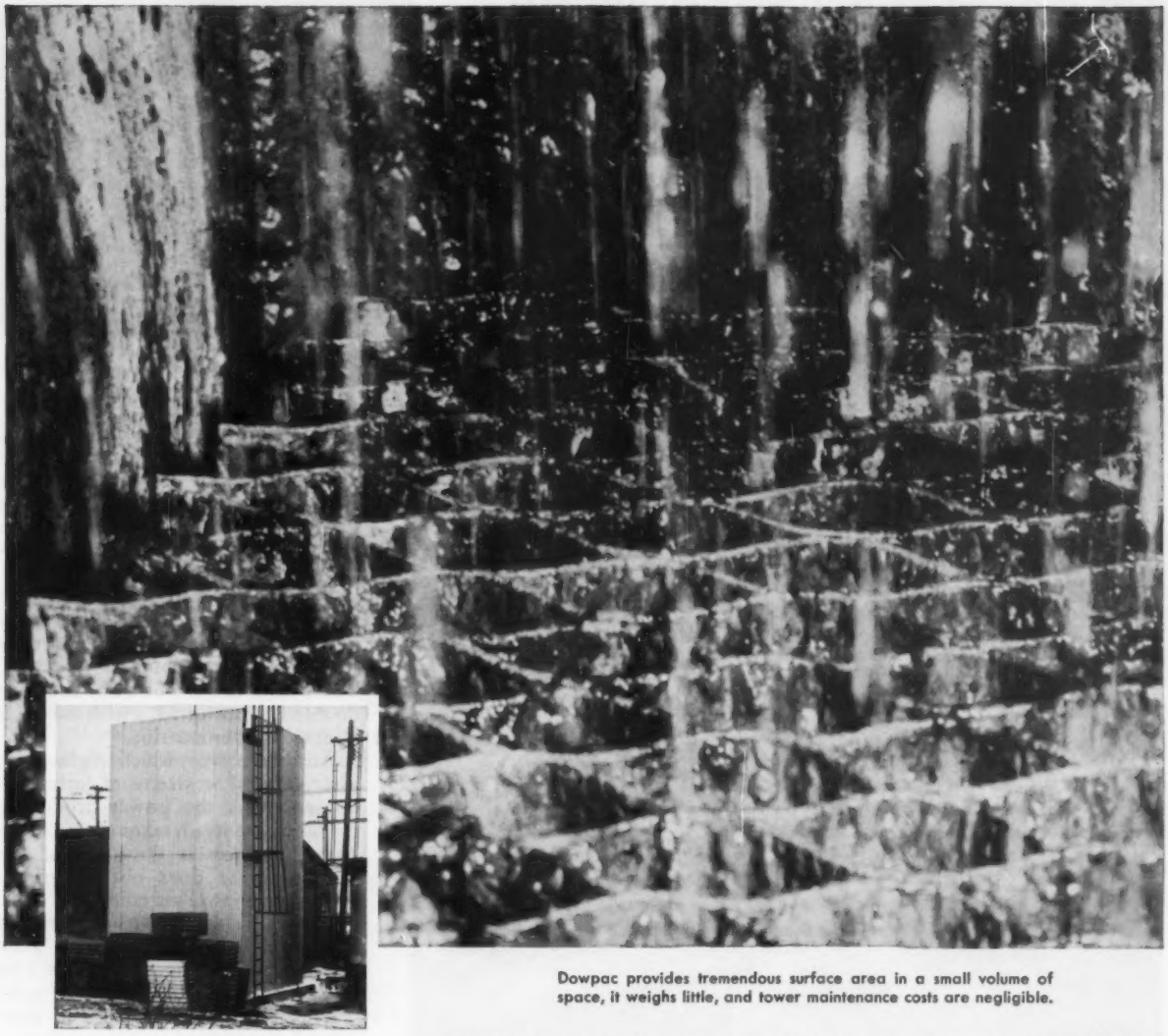
The summing up. Management development has moved from the old autocratic form of do-it-yourself-ism (or the proverbial "road of hard knocks") as a means to train managers, to the unstructured, democratic, human relations approach. Human relations has been a story of failure and success, trial and error.

Where does management development stand now? Is the emphasis still on human relations or is there too much variance in human behavior for this to work? In part two, next month, we'll try to resolve these questions, and discuss some problems in today's management development programs.

About the Author

Charles H. Vervalin is management and personnel editor for HYDROCARBON PROCESSING & PETROLEUM REFINER. He solicits, selects and edits all articles in the "As Management Sees It" section and handles the "Quick Look at HPI" and "What's Happening" news departments. He holds a B.S. degree in journalism from the University of Houston, and studied law there and at South Texas College of Law. Mr. Vervalin received his LL.B. degree from Blackstone School of Law, Chicago. On the staff since January 1958, he previously directed public relations for a professional society. He is a member of American Society of Training Directors, International Council of Industrial Editors, the Association of Petroleum Writers, and Sigma Delta Chi, professional journalistic society.

Vervalin



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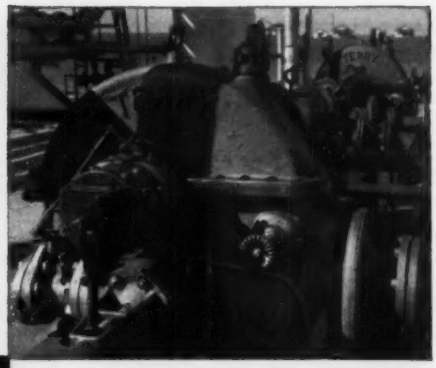

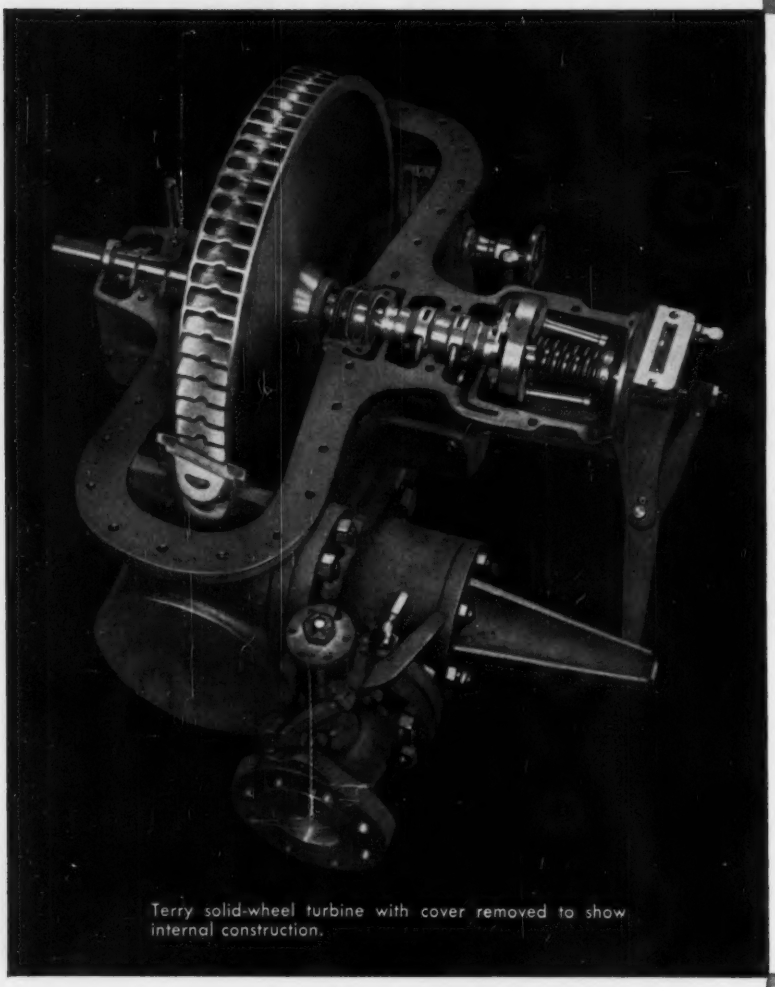

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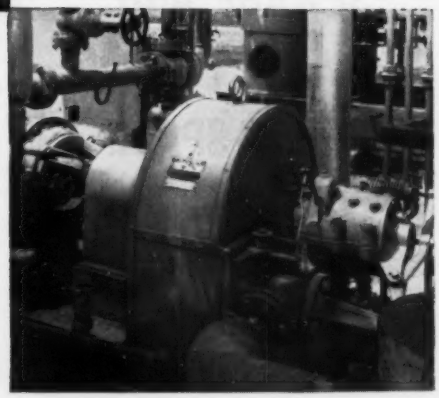

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JUDGING PEOPLE BY PSYCHOLOGY—PART 1

TO KNOW OTHERS--KNOW YOURSELF!

'Know thyself' is a saying worthy of all men to be received. Here are the basic principles of human behavior that will help you understand yourself—and others—better

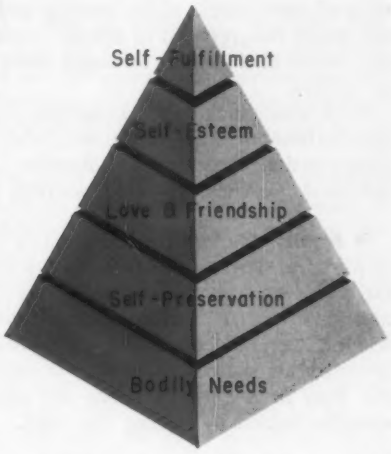

FIGURE 1—The five needs of man are like a pyramid, with bodily needs as a foundation and self-fulfillment at the apex.

John D. Quinton, Tennessee Gas Transmission Co.

It is axiomatic that a person cannot understand others unless he first understands himself. And in spite of all the time we spend thinking about ourselves, it is appalling how little we know about the psychology of our makeup.

To be able to answer such questions as: Why do people act the way they do? Why is it that a plain-looking secretary is very popular and the beautiful one shunned by others? Why did Jack "blow his top" when all Sam did was slap him on the back? Why did Joe, who had "everything to live for," commit suicide?

These are just a few of the many questions we ask about *others*. To help understand them, it is wise to analyze our own psychological makeup. Once we do this, we can better see why others act the way *they* do. To bring about this self-understanding we must have a full comprehension of human nature as it operates in day-to-day activities.

A deep analysis of fundamental human behavior is necessary for men and women to understand themselves—and others—better than ever before.

Stereotyping. But, you ask, isn't the understanding of people nothing but "common sense?" To give this age-old question a run for its money let's check out some "common sense" beliefs that have been handed down for generations. These beliefs, which the psychologist calls *stereotyped* ideas, are among the foundation blocks supporting our understanding of others. And, more important, *critical business and personal judgments and decisions have been made on the assumption that these beliefs are facts.*

So—let's test our "common sense." The following statements (or myths) have been examined critically in carefully designed and controlled psychological experiments, where the truth or falsity of each was ascertained. And, incidentally, checking our beliefs against experimentally known facts is a very important discipline. If we don't, we can go blindly through life making important decisions based on false judgments and beliefs.

• **Myth.** You can judge a person's intelligence by just looking at his face. **Facts.** Not true. Many experiments have been done where people judged intelligence by using a group of photographs. These photos were of people of all intellectual levels. The judgments proved no better than chance. We must be around a person a long time before we can judge his intelligence accurately.

• **Myth.** Children with high I.Q.'s are likely to be weak physically. **Facts.** Not true. In fact one study of 1,300 gifted individuals over a period of 25 years showed that the death rate of these people was significantly lower than average. In addition, there was much less illness in this group.

• **Myth.** Man has only five senses. **Facts.** Scientists do not yet know the exact number of senses we have. They do know there are more than the five commonly known

Editor's Note

In the July and August 1961 issues of HYDROCARBON PROCESSING & PETROLEUM REFINER, **World-famous caricaturist Emery Kelen discussed his theory of analyzing the personality by observing the body and face. Now his two articles, entitled "Judging People by Physique," are followed by this two part-series—"Judging People by Psychology," prepared by two well known professional psychologists. One is from industry (John Quinton, of Tennessee Gas) and one from the academic bench (Dr. Richard Evans, University of Houston). Both of these authors are well qualified to present the behavioral scientist's approach to personality analysis. Mr. Quinton has many years experience as a university teacher and as a psychologist in industry. Dr. Evans, author of Part 2 (next month), also is a teacher with broad experience. He has worked personally with the renowned Dr. Carl G. Jung, who is ranked with Sigmund Freud as one of modern psychology's founding fathers. We hope you will enjoy reading these two articles. They are written to help us learn even more about seeing people as they are, and not necessarily as we *think* they are. The thesis of these articles: Business is *people,* and understanding people is good business.**

Charles H. Vervalin
Management & Personnel Editor

ones of taste, smell, sight, hearing and touch. These are the senses that respond to stimuli *outside* the body. There are others that give us messages about the *internal* state of affairs.

Such senses include the kinesthesis, or muscle sense; the labyrinthine, or sense of balance, and organic sensitivity (heart action, breathing and digestion). In addition there are some "skin senses"—cold, warmth, pressure and pain.

• **Myth.** You can foretell a man's future by the lines in his hand. **Facts.** This procedure is called palmistry. As far as psychology is concerned this "science" is listed along with other "fortune telling" systems as a pseudo-science. Carefully controlled experiments extended over several years showed there was no reliable evidence that the lines in a person's hands are anything other than wrinkles caused by folding the hand.

• **Myth.** We can predict an artistic future for a child that has long, slender hands. **Facts.** In an extensive investigation of several hundred artists (painting, music, etc.) it was found that the type of hand structure had no relationship to the artist's success. In fact the hands ranged, as in nonartists, from short, stubby, broad hands to long, slender hands.

• **Myth.** Genius is akin to insanity. **Facts.** This can't be true because we are talking about two entirely different things. When we speak of genius we are talking about intelligence. When we speak of insanity we are talking about a mental state.

What people really mean to say is that a genius is different or "abnormal." They would be right in this respect. They are abnormal as far as intelligence is concerned. Being far above normal in intelligence causes them to act and live eccentrically at times—thus we think they are "nuts" or insane.

• **Myth.** Most people that lose their jobs are fired because they lack ability or are not well trained. **Facts.** A lack of skill or technical knowledge is not the main cause of discharge. In a study of 4,000 discharged men it was found that only 34 percent were discharged for lack of skill or technical knowledge. It was a "lack of social understanding" (another way of saying one can't get along with others) that was instrumental in getting the other 66 percent discharged. This included such items as insubordination, unreliability, absenteeism, misconduct, trouble making, violation of rules and dishonesty.

• **Myth.** You can't teach old dogs new tricks. **Facts.** The implication is that older people can't learn new techniques and procedures. Research shows that learning ability declines gently from age 20 to 50. This loss is so slight as to be insignificant. After the 50th year the declining rate increases. However, it is only at about 70 that the ability to learn new material is very low.

Many more "common sense" beliefs are instrumental in causing us to misunderstand people. But the above should warn us against making judgments about people based on past beliefs and popular sayings.

Analyze Behavior. One of the best ways to understand others and ourselves is to analyze the basic pattern of human behavior. Once we see and understand this pattern or sequence we will get some insight into why we act the way we do. For behind every act there is a reason—or more accurately—reasons. These "acts" we see (people's behavior) are actions taken by the person to adjust to some situation.

Let's trace this pattern from the cause (reason) through to the person's act. These "reasons" can be thought of as the basic human needs. A person needs a lot of things if he is going to be happy. Because he hopes to get many of them out of his job, he works, just as other people do.

There are literally dozens of needs that have been ascertained by psychologists. But for our purpose all these various needs (which can be called subneeds) can be incorporated into what is called the "five basic needs of man." Suppose we list these needs here and discuss the meaning of each:

1. Bodily Needs—A person needs food, clothing, sleep, a house to live in, a car, and so does his family.

2. Need for Self-Preservation—Frankly, he wants to stay alive. He keeps out of danger, and goes to the doctor when he's sick. Also, most people want self-preservation even after death, therefore they marry and have children to continue their likenesses and names.

3. Need for Love and Friendship—Man is gregarious—that is, he wants to live with and among other people. This need ranges from a casual "hello" to a neighbor to the deep love and affection of his parents, his wife and children. He wants to be one of the gang where he works. He wants to be liked and accepted by the people he works and plays with.

Included here, too, is the opportunity for loving and intimate sexual experience, and for parenthood; also companionsip, agreeable fellowship, happy sociality.

4. Need for Self-Esteem—He needs to know that he can do his job right, and that others have confidence in him. He needs to feel that he can face and overcome whatever problems he may have in the future. This is a sense of "I am worthy"—a sense of counting for something in one's world—of "being somebody"—of "amounting to something."

It's hard for a person to develop self-esteem entirely alone. He needs the good opinions of others to support him. He needs this self-esteem no matter where he works or what his job may be.

5. Need for Self-Fulfillment—Once a man has developed a sense of "worth" (self-esteem) he needs to prove it—to himself and to others who count to him. He needs the feeling that comes from a good job well done. It may be creative, competitive or constructive. However it comes, it must be the result of something he believes was worthwhile. It must have value to him and meaning to others.

He sets his "level of aspiration" according to his evaluation of his abilities and other personal assets (self-esteem). He then feels the need to fulfill these aspirations. He needs to sense that development of the self, personal growth, and realization of his own unique powers are occurring.

In one way or another all of us want to satisfy these five basic needs.

Do we have these needs all the time? We do! They're as much a part of us as our flesh and bones, but they don't all demand satisfaction at the same time. Also, some of them may be stronger in one person than they are in someone else, or they may be weaker, too.

These are the reasons why Joe differs from Jim. They both are alike in having the *same basic needs* but the needs differ in intensity and importance between Joe and Jim. That is why we are constantly admonished to treat everyone differently because everyone is different. But remember—the difference does not lie in the area of needs but in the intensity and importance of the needs to the person.

Like a Pyramid. The five needs are like a pyramid, as shown in Figure 1. Bodily needs form the base because they cannot be put off. For instance, Jim cannot go without food or sleep very long. Self-preservation, love and friendship, and self-esteem follow in order, with self-fulfillment at the top of the pyramid. Self-fulfillment is the last and probably the most difficult need to satisfy.

The three needs in the upper half of the pyramid are the so-called psychological needs. They are important to supervisors because they have to be satisfied to a large extent on the job.

It is important to know, too, that these needs do not stay neatly in this order of preference or importance. The importance of the desire to satisfy one of the psychological needs could take precedence over even bodily needs. For instance—a man highly concerned over saving-face (need for self-esteem) might make the need all important and put it ahead of bodily needs and self-preservation and commit suicide. You might even see evidence of the need in his suicide note in such phrases as "I could not 'face' my family," or "I could not 'face' my business partners." This illustrates the power of our psychological needs—and cautions us never to underestimate their strengths.

Appetites and Aversions. Now we know what a person needs, but how does he go about getting what he wants or needs? He acts through the "urges" that develop along with his needs. These "urges" are known as "drives." Drives are of two sorts—*appetites* and *aversions*. A drive that is an appetite takes us toward something pleasant or enjoyable. It leads us to buy a suit, to go bowling, or go to the movies, or to buy a certain kind of car. And remember, all these actions are to satisfy one or more of the needs.

A drive that is an aversion takes us away from anything painful or unpleasant. It causes Joe to wear safety goggles and steel-toed shoes—or run from a fire—or get out of the way when his wife is on the warpath.

Both appetites and aversions influence our behavior at all times. For instance, a worker wants to keep his job—therefore he has an aversion to doing anything that would cause him to lose it. However, he wants his time on the job to be enjoyable, and he hopes to improve his work so that he may get more pay or be promoted. These appetites or desires make him act so that other people will like him; he can have fun while working and they make him a better worker.

We have been talking about these appetites and aversions separately—as if they act separately. Actually, they are closely related and are often in conflict with each other. One aversion may be opposite to another—or several appetites or desires may be tempting the person at one time and there is trouble in choosing the one to be satisfied first.

A person often has inner conflict between his appetites and his aversions. As an example, let's say a soldier is walking with a buddy when some mortar fire begins. He gets the immediate urge to seek cover fast. This is a drive to avoid pain of injury and a desire (appetite) for self-preservation. If his buddy has been wounded, the soldier has a problem. Should he save his buddy and satisfy his need for friendship, self-esteem and self-fulfillment? Or should he satisfy his need for self-preservation and save himself? Under these circumstances he has to decide in a hurry. Whatever he does, it will be based upon the needs that are the strongest at this moment.

If he cannot make up his mind because the aversion drive and the appetite drive are of equal strength, he may find that he is also injured because he has hesitated so long.

Frustrations. The decisions we make to satisfy our needs aren't simple and easy in every case. Nearly every act of satisfying our needs runs up against one of the most important single influences in our lives—obstacles or barriers which cause *frustrations*. These barriers or blocks can be psychological or physical, and they come between the person's needs and his capabilities of fulfilling those needs.

The more frustrated the person gets, the more anxiety he exhibits. This anxiety is mental distress over possible and actual frustrations of his drives along with the feeling that he cannot cope with the blocks and barriers when he is confronted with them.

Out of these barriers and the resulting frustrations and the anxiety they cause, the person has emotional urges (or drives) that influence the way he acts. Included are feelings of love and hate. Love is an appetite for pleasant experiences and hate is an aversion to unpleasant or painful experiences.

The importance of the emotions should never be underestimated. And all people have emotions. The difference in the "emotional" person and the "unemotional" person lies in the ability—the will—of the individual to balance or control his emotions.

To illustrate emotions at work, suppose a worker goes to his supervisor about his job. The supervisor is busy or irritated and puts his employe off, refuses to explain, and dismisses him abruptly, and unsympathetically. How will the employe react? He will go away displeased and dissatisfied. With repeated encounters such as this with the supervisor, the employe gradually reacts with the emotion of hate—or at least with dislike.

Points to Remember. Before we go further into this pattern of human behavior let's trace the pattern thus far:

1. Man has five basic needs.

2. He tries to satisfy these needs by following the urging of his drives—both appetites and aversions.

3. These drives can cause inner conflicts which have to be resolved before the needs can be satisfied.

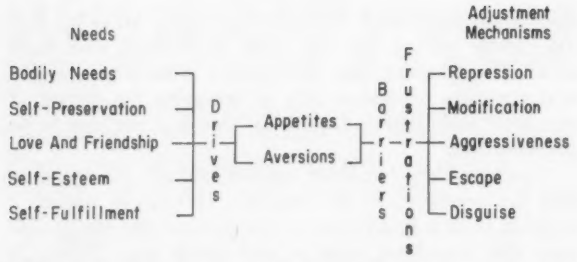

FIGURE 2—This sequence of human behavior helps us understand why we and our acquaintances act the way we do.

4. Every drive is opposed either mildly or intensely by barriers which cause frustrations.

5. These frustrations cause the person to become anxious because they are a threat to the satisfaction of his needs.

6. Whatever a person does is influenced by feelings or emotions toward others.

A person, then, acts to satisfy his basic needs. But he gets frustrated when some barrier blocks his endeavors. This brings up the question: "What do people do about these frustrations?"

Well, let's take a person through five major types of things he can do when he meets these barriers and becomes frustrated. They are **aggressiveness, modification, escape, repression,** and **disguise.** These five responses (or adjustment mechanisms), or some combination of them occur every day—on and off the job. We see them first because they are the outer signs (acts) of a person's reactions to frustrations. The more we understand them the better our chances of understanding why we and others act the way we do.

AGGRESSIVENESS

As an illustration of an aggressive response to a barrier, let's say an employe is assigned to repair a pumping unit. He does the obvious, practical things and still the engine will not work. At first there is mild frustration and he tries to lick the problem with more aggressiveness.

He tries several new approaches—if none works he tries another. He may check the manual or ask his boss for information. All of these responses show *positive aggression,* in which constructive action has been taken. The employe continues until he finds the source of the trouble.

On the other hand, the mechanic may show *negative aggression.* When the pumping unit engine will not start, he may become frustrated, then emotional and finally "blows his top" and hits the engine with a hammer. This is destructive aggression and accomplishes nothing constructive.

Negative aggression may be used in many instances. Its primary characteristic is action toward some thing or person which is a result of frustration, but is not aimed at overcoming the frustration itself. It is detrimental to both the employe and the recipient of his aggression.

There is another aspect of aggression we should note before moving on. This is *displaced aggression.* This occurs when we do not know what the barrier is that is frustrating us or we cannot afford to attack the barrier. (For instance—the boss.) We remain highly frustrated and when we leave the job we "take it out" on someone or something. The little woman at home and even the children, can attest to this in many cases.

MODIFICATION

Another mechanism we all use to some extent is modification. We are confronted with a barrier that cannot be overcome or we do not wish to "pay the price" of overcoming it so we modify our behavior. For example, Sam might want to be a doctor but when he is confronted with the barriers—eight years of schooling and substantial expenses—he gives up his plans and satisfies himself with a B.S. degree in medical technology.

Here Sam has modified his original objective to a new objective, thereby changing the barriers (8 years to 4 years and much less expense). Sam has handled the original barriers (and the resultant frustrations) not by overcoming them but by going around them.

As long as Sam is happy and satisfied with his decision his use of the modification mechanism to relieve his frustration has been successful. This brings to focus two factors of happiness: One is that "a wise man can change his mind but a fool never does," and second, there are times when we can't get everything we want and must be satisfied with what we can get.

ESCAPE

There are times when all of us try to escape from our frustrations. There are various types of escape. First, there is the quitter. When things get too tough on the job, the boss is intolerable, and the work is dissatisfying—the employe may quit. This is not a "bad" thing under certain circumstances where the "barriers" to satisfaction and happiness cannot be overcome by the employe. But when no real effort is put forth to solve the barriers it can become unhealthy. The employe may quit so often that it becomes a habit and he ends up as a "job nomad" or "drifter," who never stays long enough in one place to beat the barriers.

Then there is the daydreamer. He lives a secret life of his own in which he solves all his problems and, mentally, never is frustrated. The handicap here, however, is that he never gets into reality so he can solve his everyday problem. Daydreaming is not all bad though. Most of us escape temporarily through "building air castles" now and then. But then we shake our heads, come back to reality and face our problems (barriers).

Another method of escape is through "store bought" mediums such as movies, magazines, card playing, TV, etc. This is quite normal for all of us unless we go to the extreme and use these all our waking moments.

Keeping too busy is another type of escape. The man who buries himself in work both at the office and every night at home, is escaping from the problems of his personal life. He usually feels that the problems are unsolvable or so unpleasant that he avoids them entirely.

Or a man may constantly refuse added responsibilty on the job because he is afraid he cannot solve the problems (barriers) of the added responsibility. He forms the habit of stopping just before he gets to a barrier in order to avoid it.

One of the common forms of escape is through the use of drugs and alcohol. We physically do not need either

of these, but psychologically some people need them to escape the realities of life.

An important point to remember about the "escape" mechanism is that used in moderation it helps us face our day-to-day barriers. Used in the extreme it is dangerous.

REPRESSION

In many of the illustrations given here it is noticeable that the person can be using certain adjustment mechanisms unknowingly. Another mechanism, repression, certainly is true in this aspect because it could be called "protective forgetting." Psychologically painful barriers are put out of the mind. If we remain unaware of a barrier or problem, we don't have to search for a solution.

Another aspect of repression is when a person "represses" his feelings and emotions. He is really bottling his frustrations and problems up inside himself. It is a form of over-control of the emotions, and many times it is difficult to know when a person is repressing his drives.

There are some indications of repressed drives we may see from time to time in a person. Sometimes a person will appear to be lazy or indifferent. He gets out of all the work and responsibility he can. His unconscious mind may be causing this behavior to protect him from the problems of responsibility.

Again, we see repressed drives coming out as illnesses, stomach disorders, headaches, severe pains, etc. If a medical examination shows nothing physically wrong, repression of drives is at work. These illnesses protect him from the barriers he dreads or fears.

One danger of repressed drives is the possibility of a person "blowing up" and causing himself and others great harm. Overcontrol, or extreme repression, is as mentally unhealthy as no control of emotions.

DISGUISE

This is better known as "rationalization"—the ascribing of false reasons for one's behavior instead of the real reasons.

One of the most familiar of rationalizations is Alibi Ike. He's the one who, after missing the baseball, says, "Oh, the sun got in my eyes," or "I stepped on a rock." This is also a form of "projection." We project our own weaknesses onto other things or people. Like the child that says, "I'd have passed that English but the teacher had it in for me." The danger here is that we may use these so often to protect our egos that we do not have time to actually develop ourselves so we can overcome the weaknesses (barriers).

Other forms of rationalization are the "sour grapes" and "sweet lemon" attitudes. Sour grapes is illustrated by the person who builds up elaborate excuses for not wanting a large, expensive car—it's too big, don't like the design, parts cost too much, etc. The real reason? He can't afford it. But to admit that would be too much of a blow to the ego. So—he gives false reasons to protect the ego.

The sweet lemon is expressed by the person who says, "Well, that's fate. Nothing I can do. It's all for the best." The real reasons are that they don't want to exert the energy and effort to do anything about it.

Some other false reasons you will recognize: A father buys an electric train "for his son"; a man drinks "to be sociable," a large powerful country invades a small country to "protect the little man"; a man resists the change to new machinery because he has the best interest of the company at heart.

As one can plainly see—the use of rationalization to the extreme really does damage to one's self. Because it is a form of self-deception as much as it is the deceiving of others. "To thine own self be true" should be the byword of the person who really faces his barriers with the idea of overcoming them.

These five adjustment mechanisms,

- **Aggressiveness**
- **Repression**
- **Modification**
- **Disguise**
- **Escape**

are the responses we make throughout our lives. It will help to see the behavior sequence, diagrammed in Figure 2. Knowing this sequence will help us understand why we, and our acquaintances, act the way we do. There will be better understanding and tolerance of our fellowmen. One of the main reasons we don't understand the actions of a particular person is because we judge him by the strength of *our needs*—not his. Therefore we cannot justly say, "If I were you, I wouldn't do that." We would do it too—because we would be *them*—with *their needs, their barriers, their frustrations,* and *their adjustment mechanisms.* Once we understand why a person behaved in a certain way we become sympathetic and understanding instead of angry, impatient and intolerant.

It is very difficult to understand ourselves and others. But the behavior clues outlined here can help us. But be careful—the chances that an untrained person can and will make unfair and inaccurate judgments are more than possible. Perhaps the real value of such an outline is for us to develop a wholesome respect for the complexity of reasons behind our acts and to realize that those reasons are very difficult to analyze.

Key Words for Indexing

Employes **Personnel**
Management **Supervision**

NEXT MONTH: Part 2 of "Judging People by Psychology" will be presented by Dr. Richard Evans. The title: "Stereotypes Can Wreck Human Relations."

About the Author

John D. Quinton is a training representative for Tennessee Gas Transmission Co., Houston, where he develops and presents training programs. He holds a B.A. degree in psychology from Lincoln Memorial University and M.A. degree in psychology from the University of Tulsa, and has completed most of his work toward a Ph.D. degree at Kansas University and the University of Houston. He has taught psychology at Kansas and Tulsa universities, and has headed the Psychology Department, Arkansas Polytechnic College. Mr. Quinton was a consultant for Service Pipe Line Co., Tulsa, for two years, and training representative for Shell Pipe Line Co., for four years before joining Tennessee Gas.

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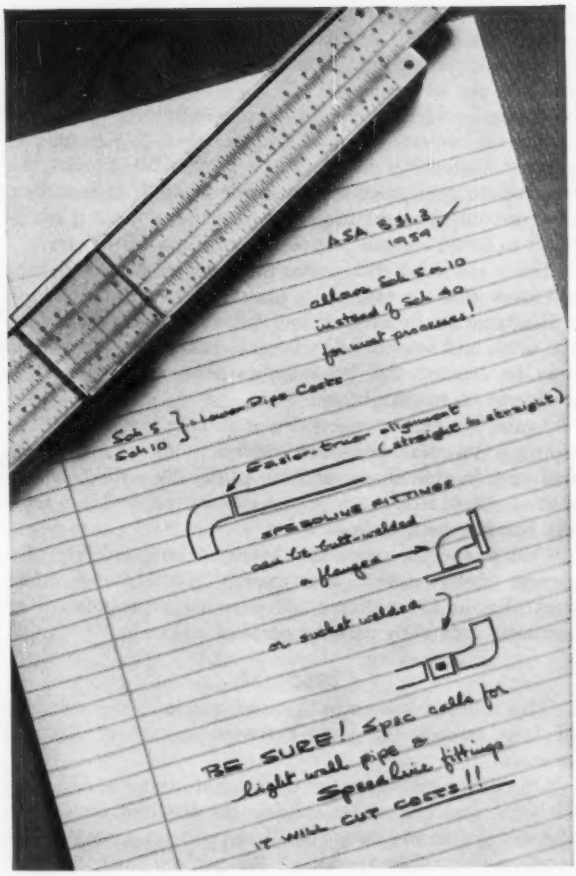

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How Conoco Teaches Leadership Fast

In a fascinating three-hour session, Conoco is teaching line supervisors the dynamics of leadership—in a way they'll never forget. Here's how they do it

Roy Clifford
Continental Oil Company, Houston

Most supervisors follow a set *style* of leadership in dealing with subordinates. As leaders, they play one certain *role*, or set part, which from their experience and point of view is the way to deal with subordinates. But often, supervisors are unaware that the type of leader they portray actually prevents group harmony and effective work—that to act differently would bring about entirely different responses from a work group.

It is important for the supervisor to realize that he can be more than one kind of leader—that he can get different responses from subordinates by varying the way he leads. It is important that he see the impact of his actions on others—that he see himself as an actor on a stage.

First, let's look at the three basic types of leadership—then we'll have a case history telling how Continental Oil demonstrated them to its supervisors, *without their realizing that the demonstration was taking place.*

Leadership Types. The three basic types of leaders are *laissez-faire, autocratic and democratic.* Here's how they operate.

- The *laissez-faire* leader imposes no organized control and gives no direction. Each man in the group makes his own decisions and goes his own way. The leader is merely there.
- The *autocratic* leader imposes authority from the outside. He gives orders, makes decisions, and controls information. He controls the group through fear.
- The *democratic* leader helps the group make decisions. He encourages opinion giving, participation, and promotes a feeling of accomplishment within the group.

These types of leadership do not exist in pure form. A leader is not all laissez-faire, or all autocratic, or all democratic. Instead, he usually *leans* toward one of these leadership styles in dealing with subordinates.

The important thing is that there is a pattern to the way subordinates react to the three leadership styles. Subordinates respond differently to each kind of leader in terms of cooperation, motivation, growth, and morale.

You Must 'See' Yourself. One way to make supervisors aware of the different styles of leadership is to let them experience the feelings and attitudes that *followers* have under each of the three approaches. By being momentarily in the subordinate's shoes, the leader can better see the impact of his own actions on others.

How Conoco Does It. A successful program of demonstrating leadership types is being used at Continental Oil. In a three-hour training session entitled "Working with People," these leadership styles are demonstrated without participants knowing the session is only a *portrayal.* From this session, new line supervisors see first-hand how an employe might respond to the different leadership styles. Here's how it works.

LAISSEZ-FAIRE LEADERSHIP

The instructor is introduced to a group of 25 or 30 line supervisors as a substitute speaker, who will discuss the subject, "Working with People." The group has previously listened to high-caliber instructors handling formal sessions on such subjects as "The Supervisor's Job," "The Company's Philosophy of Management," "Business Economics," etc. Also, to create tension and sympathy for the instructor's performance, one or two members of top management are introduced as session observers.

The instructor appears on the podium nervous and ill-prepared. He talks vaguely and incoherently about the

seriousness of his subject and the importance of people and their feelings. He mentions his inadequacy in discussing such an important subject. Long embarrassing pauses occur during which he appears nervous and helpless.

Unless natural leadership fills the vacuum, he eventually gives vague instructions for the participants to develop ideas on "HOW TO GET PEOPLE TO DO SOMETHING." He sits down at his podium table giving the impression that he, too, might develop some ideas. He stares helplessly at the pages of some textbooks he has on human relations.

At this stage, participants generally will sit looking at such other. Some will write something—some will just wait. Twenty minutes may elapse during which the instructor appears helpless and gives no instructions whatsoever. Forms of leadership eventually develop among the participants. There are long agonizing talks by volunteers. Confusion may develop over what to do with the ideas some people have written on their paper.

The group then arrives at a kind of "tension climax." That is, some people in the group have become so sympathetic for the leader that further inactivity is unbearable. In some cases volunteers will actually develop a form of direction and order. When the estimated "tension climax" in terms of sympathy is reached, or natural leadership has developed direction and strength, the instructor dramatically switches his role.

AUTOCRATIC LEADERSHIP

The role switch is made by the instructor forcefully announcing that he doesn't like the present project or what the group is doing, and "I WANT TO DO SOMETHING ELSE." He quickly moves among the participants dramatically assigning them to work groups. He assigns group leaders—"YOU, YOU, and YOU." When people react negatively to his command he tells them to SHUT UP.

At the time the dramatic switch is made, some participants have become so disarmed by sympathy for the instructor's situation that they react to his commands automatically. Others jokingly play along. Still others seem to experience a form of shock and fear, since the instructor's actions are seemingly wild and unpredictable. (Later in the session, the group will discuss the effects of inability to predict a leader's action.)

The instructor now gives each group a vague project. "YOU LIST SOMETHING ON HOW AN EMPLOYEE CAN BE A BETTER EMPLOYEE." YOU LIST SOMETHING ON WHY YOU ARE NOT A GOOD SUPERVISOR FOR THE COMPANY." He assigns projects in such a manner that no group knows what the others are doing.

At this point much depends upon the instructor's skill in keeping the group from getting out of hand. Movement and fast instructions on his part seem important, since the participants do not have a chance to think or resist.

To further demonstrate autocratic leadership, the leader goes among the training groups rewarding and punishing. The word "I" is used consistently. "THIS GROUP IS DOING WHAT *I* TOLD THEM TO DO," "YOU ARE NOT DOING WHAT

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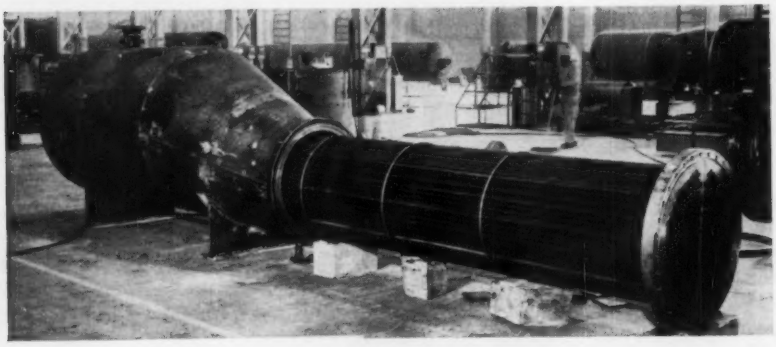

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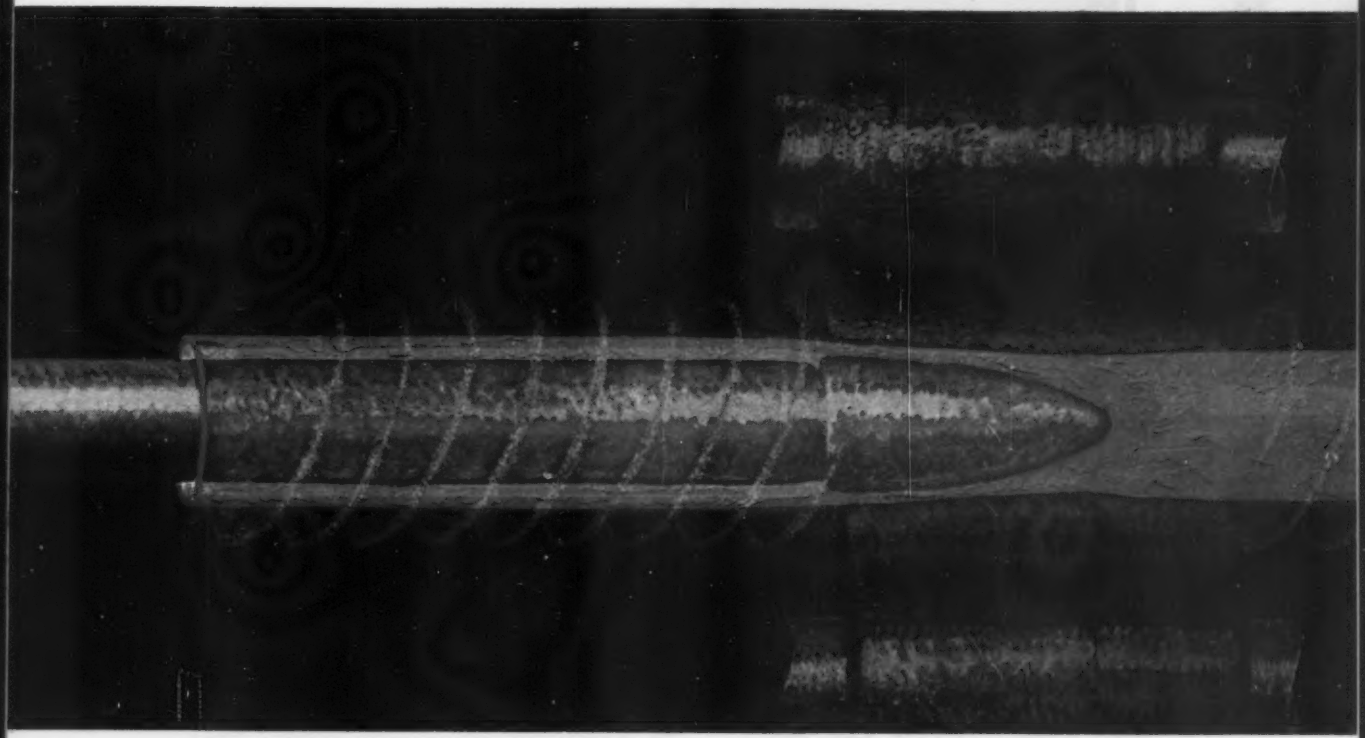

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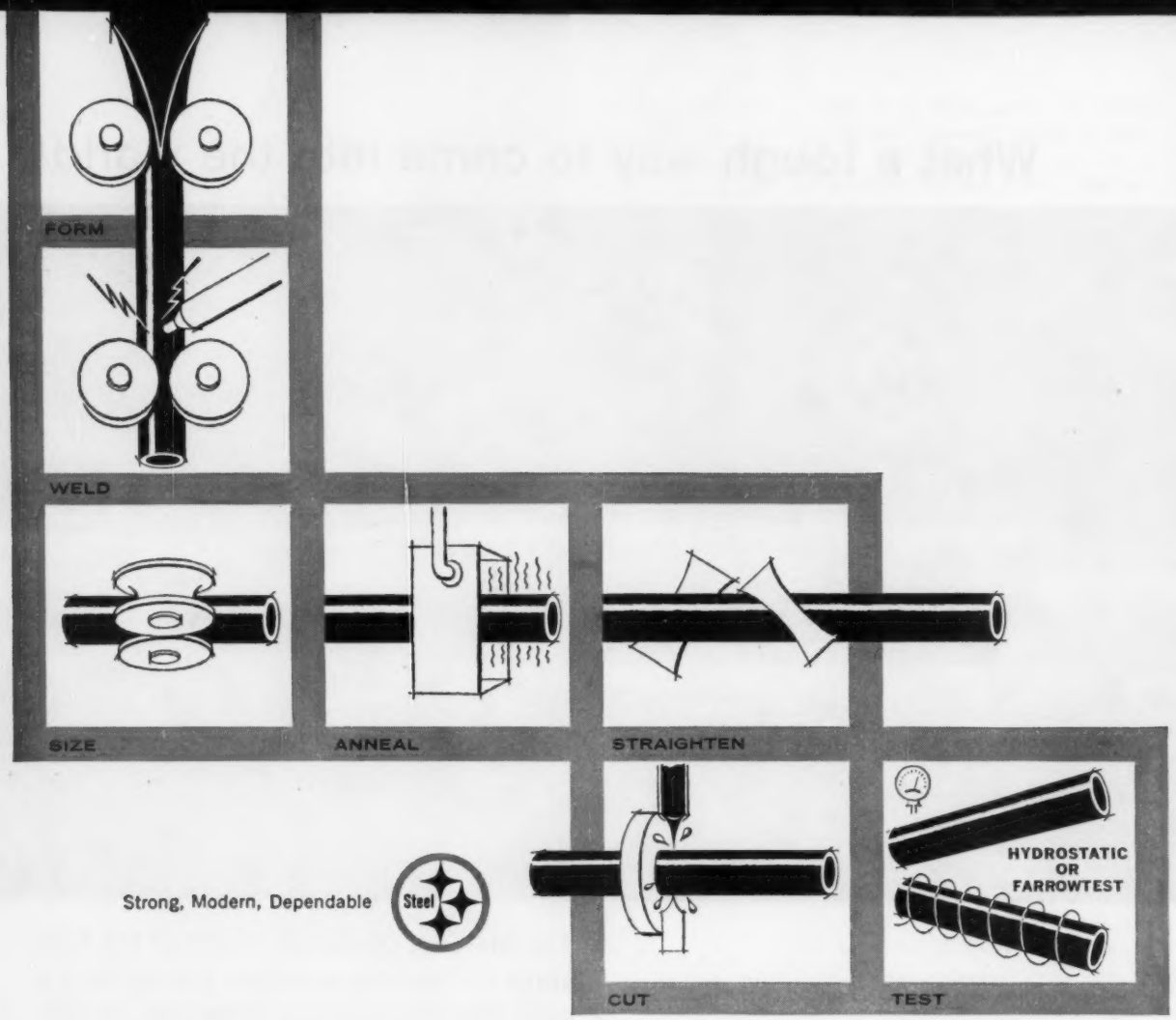

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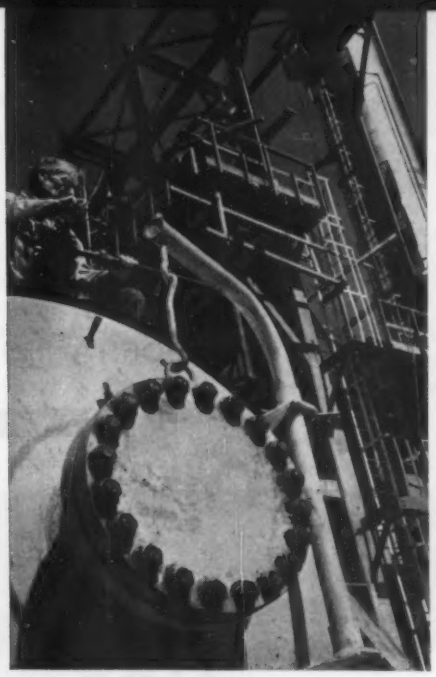

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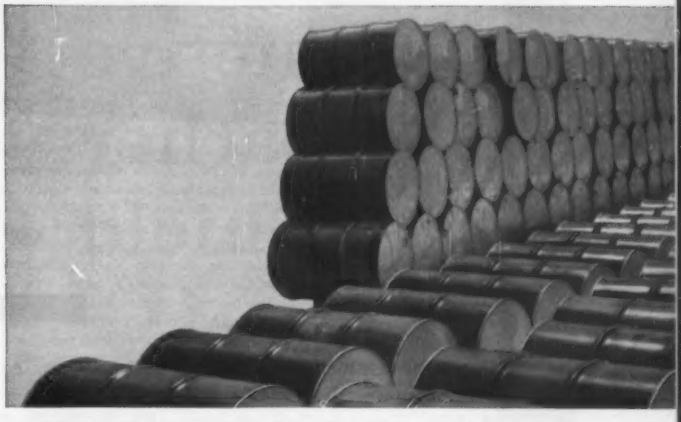

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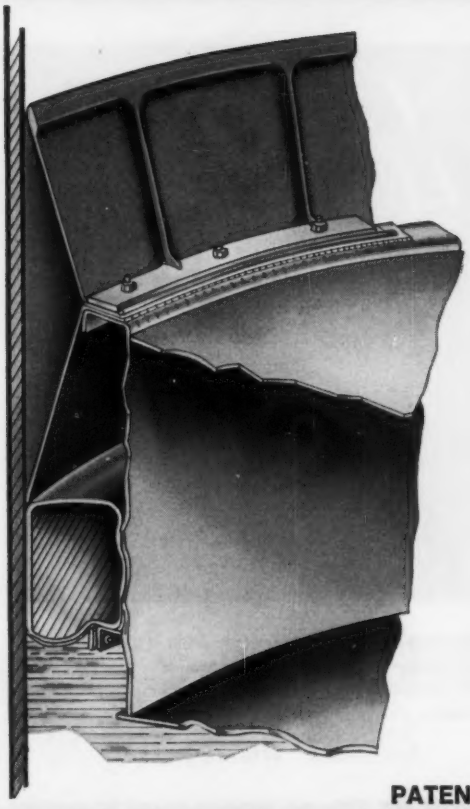

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I TOLD YOU TO DO, *I* TOLD YOU *I* WANTED YOU TO . . ."

When the groups have reached the point of actively working on their vague projects, they are interrupted. The instructor tells them to stop their projects and gives them short, step-by-step instructions:

(1) Take a piece of paper.

(2) Write down the name of two people in your group.

(3) Mark an X by the name of the man you like the best.

(4) Pass the paper in. (Later in the session, these papers are torn up.)

The action demonstrates how autocratic leaders often ask for highly personal information without giving reasons why, or a feedback on results. It is also designed to show the sense of frustration resulting from interruption.

After the personal information is obtained, the instructor has the groups return to their projects. He continues to reward and punish, to be vague about what he wants, and to be super-critical of any complaints. He constantly refers to the fact that this is a training session and that they are here to be developed and trained.

At one point he gives instructions to a "plant" in the group to get him a soft drink. He drinks this in front of the group with no concern to their lack of refreshment. (This demonstrates how autocratic leaders often ask subordinates to do highly personal subservient things to assert power.)

At the end of the autocratic exercise the leader announces that they did a good job—did just what he wanted them to do, which was to develop a list of the "needs of people." He shows them a flip chart on which he has these needs listed:

(1) Security

(2) Personal achievement

(3) Sense of belonging

(4) New experience

It is obvious to each participant that all of the group's work has been for nothing, because they have been working on the wrong project. The instructor has done all of the thinking, and the finished project is his own. (This demonstrates that autocrats often keep people busy only for the sake of order giving. They do the real work themselves).

ACTION ANALYSIS

At this stage in the session the leader dramatically indicates that the fun is over. "Kings X," I don't need a psychiatrist. Let's take a look at what has happened here. He points out that he has acted toward the group in two definite ways since the session started. He asks the group to analyze their reactions to the two roles he portrayed.

By this action of the instructor, the participants have a great desire to find emotional release in talking. Some want to immediately say that they were aware of what was happening all along. Some tell of their great sympathy for the instructor during the laissez-faire demonstration. All are stimulated to discuss and analyze their reactions to both experiences.

Laissez-faire Analysis. The instructor asks the group to analyze their responses to the laissez-faire demonstration—their lack of direction, their feelings of being lost, and their feel-

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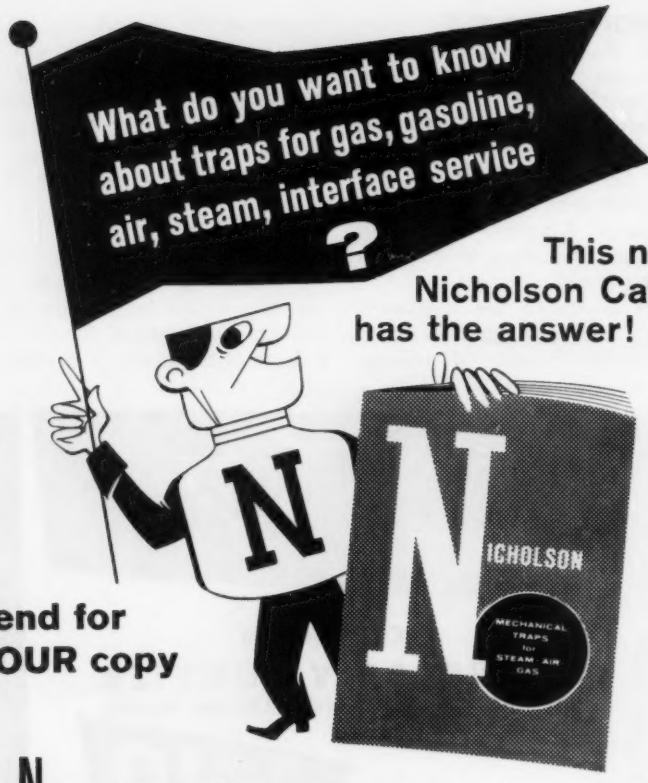
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ings of sympathy and perhaps contempt for the leader. Characteristics of the laissez-faire leader, similar to the following, are developed in the discussion.

1. Leader does not know where he is going and lets group run him.
2. There may be no rules.
3. Subordinates set work pace and standards which may be haphazard.
4. Subordinates make individual decisions.
5. Subordinates do not fear leader.
6. Work goes at same slow pace when leader is not around.
7. Subordinates may be aggressive toward leader.

Autocratic Analysis. Following the laissez-faire discussion the group is asked to analyze the autocratic demonstration—their feeling of domination, separation, and lack of dignity. Characteristics of the autocratic leader, similar to the following, are developed.

1. Leader makes all decisions.
2. Leader hides goals of project, etc., from subordinates.
3. Leader parcels out jobs in a detailed fashion—step-by-step.
4. Leader depends upon and uses his authority.
5. Leader sets work standards.
6. Leader makes many rules.
7. Subordinates fear leader.
8. Subordinates may not get satisfaction as people.
9. Work of employes may let down when leader leaves work place.
10. Subordinates have a sense of dependency and order.
11. Subordinates may be aggressive toward leader.
12. Leader rewards and punishes.
13. Leader goes in for procedure and ritual.

The group spends much time defining and labeling the various events and their reactions. Through this labeling process, common terms develop, and the whole panorama of

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signal action

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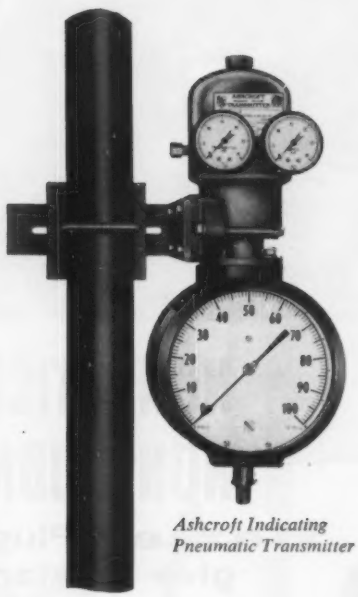

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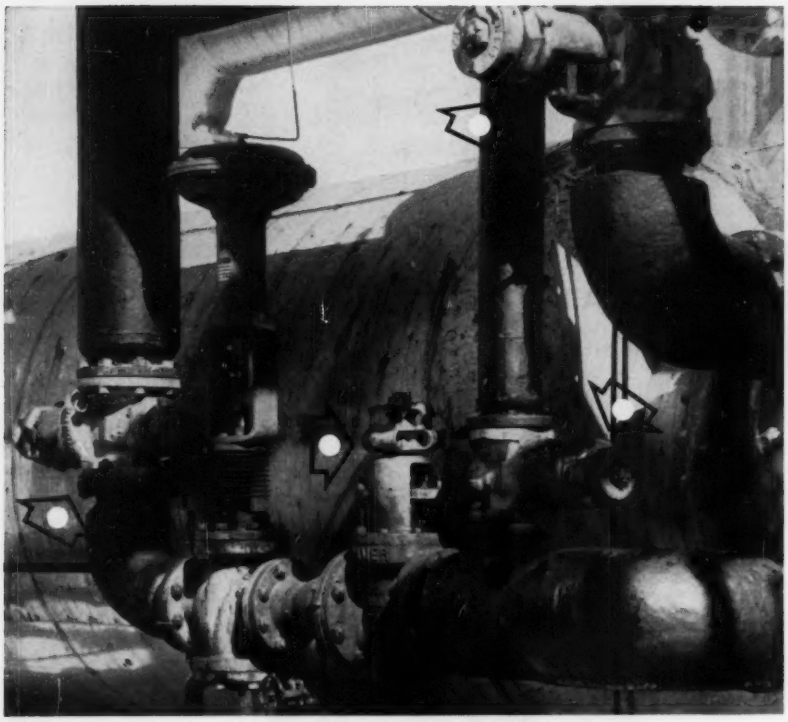

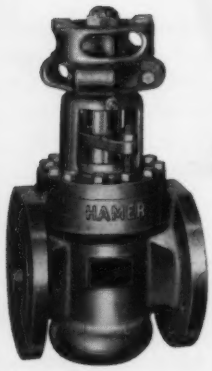

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leadership styles and reactions becomes open for discussion.

"WHAT SORT OF LEADER IS COCHISE?" "IS HE A BENEVOLENT AUTOCRAT?" "WHAT SORT OF RESPONSE DOES HE GET FROM HIS INDIANS?" "IS HE PATERNALISTIC?" "WILL HIS TRIBE WORK WHEN HE IS NOT AROUND?" "WHAT SORT OF LEADER WAS WARD BOND ON 'WAGON TRAIN'?" "JOHN WAYNE IN 'RED RIVER'?" "WHAT SORT OF LEADERS WERE ROOSEVELT, TRUMAN, OR EISENHOWER?"

The exercise stimulates many ideas and opinions on the difficult relationship between leader and follower.

DEMOCRATIC LEADERSHIP

When free discussion has subsided, the instructor tells the group that he has now demonstrated a third style of leadership. He points out that during the period in which the group discussed their reactions to the demonstration and developed characteristics of the laissez-faire and autocratic leaders, a new leadership climate was established.

He tells them that during this discussion period he has portrayed the role of a democratic leader. He asks the group to analyze their responses to the discussion period, their feelings of participation, security, and sense of working together. Characteristics of a democratic leader, similar to the following, are developed.

1. Leader helps group make decisions.
2. Leader is a sort of member of the group.
3. Subordinates may suggest rules and agree upon them.
4. Work standards and work goals are developed and agreed upon by group.
5. Subordinates understand the big picture.
6. Subordinates do not fear leader and leader does not abuse authority.
7. Subordinates sense order but not dependency.
8. Work continues at a relatively

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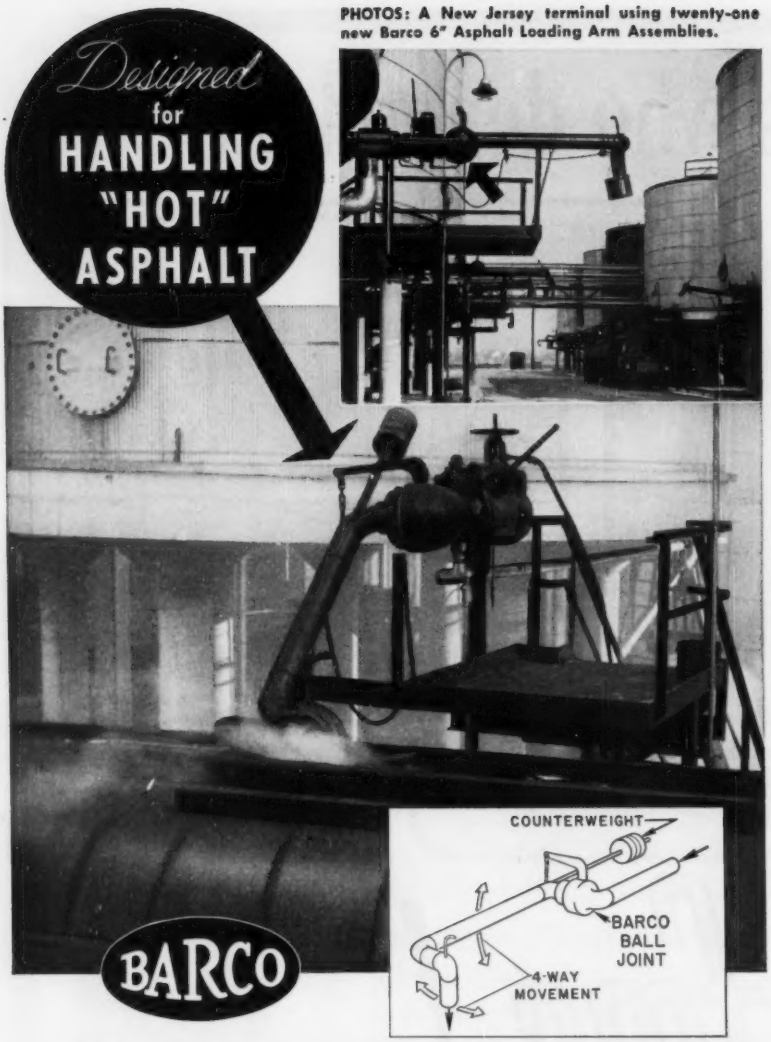

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- ☑ **FIRE SAFE!** Barco Ball Joints have passed rigid Fire Tests for refinery and chemical plant service.
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high pace when leader is absent.
9. Subordinates are not aggressive toward leader.

The balance of the training session covers a flip-chart presentation, role playing, and a discussion of leadership problems the various group members have faced.

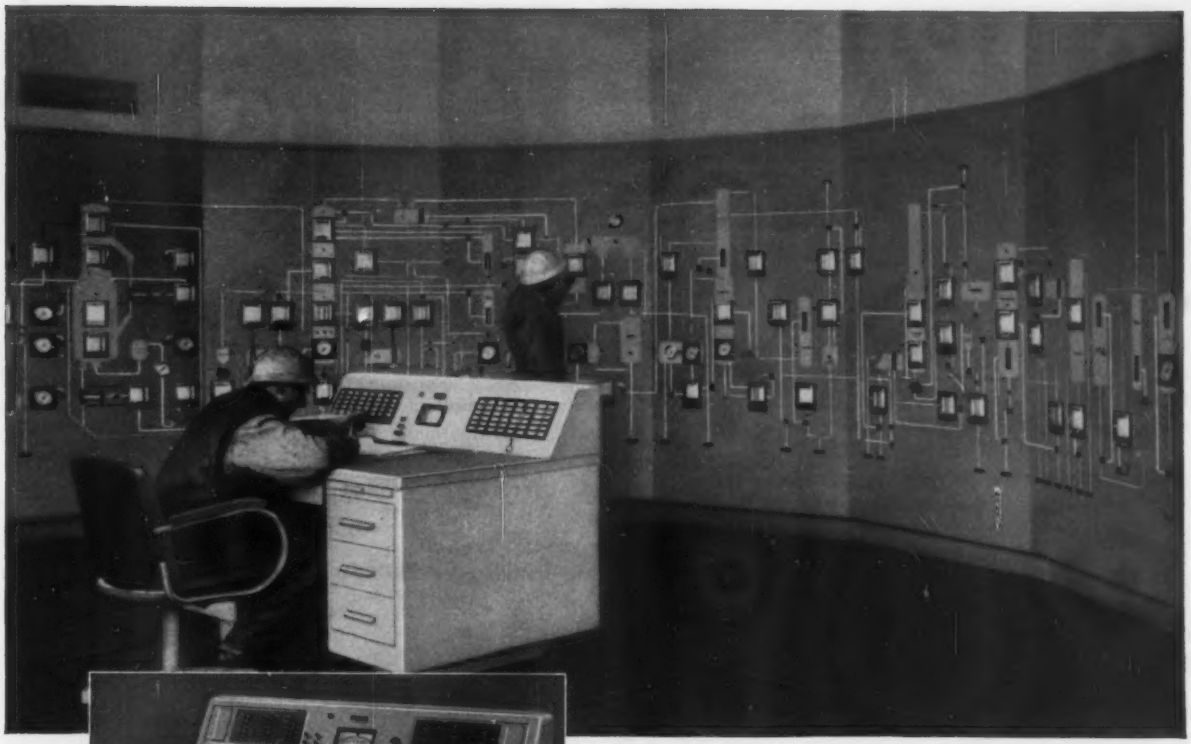
CONCLUSION

This session has been conducted with many supervisory groups. In all cases, audience response to the mechanics of the demonstration has been the same. The success of each session depends upon the skill of the instructor, because it takes a degree of actor's skill to carry the laissez-faire demonstration to the point of maximum sympathy.

All participants have been asked to prepare anonymous evaluations following each session. The general consensus is that the session gives them a framework for analyzing and understanding the leadership tendencies of their superiors and makes them more aware of the effect of their own actions on others. Most important, they feel the course is more than "just another session on management training"—it's an *experience* and one they will long remember.

About the Author

Roy Clifford is assistant director of the Employe Communication Division, Continental Oil Co., Houston. He was formerly assistant director of industrial relations for the company's Petrochemical Department, and has performed industrial relations work in four major departments at Continental Oil. Mr. Clifford received his B.A. degree in radio production and advertising and M.A. degree in sociology and economics from The University of Texas. An active member of a number of training and personnel professional societies, he has spoken before various management training groups in the Southwest and has taught management courses at the university level.



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How to Do It...

Check Furnace Air Deficiency When Burning with Excess Air

I. Grimberg, Haifa Refineries, Ltd., Haifa, Israel

There are many different probable causes which could promote imperfect combustion in furnaces where the excess air is below certain limits.

Whenever a simple Orsat flue gas analysis shows more percent O_2 than expected by the fuel chemical composition and percent CO_2 found, it is time to check to see if CO is present in the flue gases. (See nomograph—HYDROCARBON PROCESSING & PETROLEUM REFINER, September 1961, p. 286.)

When the percentages of CO, CO_2 and O_2 in the flue gases are known, the following quantities can be determined:

- Air deficiency
- Air excess
- Heat loss by imperfect combustion.

Evidently, CO gas as a product of imperfect combustion is accompanied by H_2, and their volumetric ratio (H_2/CO) is dependent for each furnace on several factors such as fuel composition, flame temperature, etc. This volumetric ratio should be determined for each refinery furnace, but as a starting approximation we may use $H_2/CO = 2.0$ which has been expirically found (1) for usual refinery gaseous and steam-atomized fuel oils and which corresponds to the equilibrium concentrations for a water-gas type reaction at about 1,000° C.

In Table 1, you may find the different possibilities and see that the heat loss is not so much dependent on the H_2/CO ratio as it is on chemical composition.

TABLE 1—Air excess, deficiency and heat losses as functions of percent CO, CO_2 and O_2 in dry flue gases.

$\frac{H_2\ (Vol.)}{CO\ (Vol.)}$ Ratio in Flue Gases	dr	$\frac{e}{d}$	Heat Loss, L, Btu/lb
0	$0.5\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{0.5}\left(\frac{O_2}{CO}\right)-1$	$60{,}800\left(\frac{r.d}{2+r}\right)$
1:2	$0.75\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{0.75}\left(\frac{O_2}{CO}\right)-1$	$57{,}800\left(\frac{r.d}{2+r}\right)$
1:1	$1.0\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{1.0}\left(\frac{O_2}{CO}\right)-1$	$56{,}000\left(\frac{r.d}{2+r}\right)$
2:1	$1.5\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{1.5}\left(\frac{O_2}{CO}\right)-1$	$54{,}800\left(\frac{r.d}{2+r}\right)$
3:1	$2.0\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{2.0}\left(\frac{O_2}{CO}\right)-1$	$54{,}100\left(\frac{r.d}{2+r}\right)$
4:1	$2.5\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{2.5}\left(\frac{O_2}{CO}\right)-1$	$53{,}600\left(\frac{r.d}{2+r}\right)$
5:1	$3.0\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{3.0}\left(\frac{O_2}{CO}\right)-1$	$53{,}300\left(\frac{r.d}{2+r}\right)$
6:1	$3.5\left(\frac{CO}{CO+CO_2}\right)$	$\frac{1}{3.5}\left(\frac{O_2}{CO}\right)-1$	$53{,}100\left(\frac{r.d}{2+r}\right)$

Example. Orsat analysis of flue gases dry basis:

$\%CO = 0.5;\ \%CO_2 = 9.5;\ \%O_2 = 7.5$

Assume Ratio $\frac{H_2}{CO} = 2.0;$

Fuel composition: C_2H_4

$$r = 1 + \frac{4}{2 \times 4} = 1.5$$

$$dr = \frac{1.5\ (0.5)}{(0.5 + 9.5)} \ldots . d = 0.05$$

Air deficiency = 5 percent

$$\frac{e}{d} = \frac{1}{1.5}\left(\frac{7.5}{0.5}\right) = 10 \ldots . e = 0.50$$

Excess air = 50 percent

$$\text{Heat loss} = 54{,}800 \times \frac{dr}{2+r} =$$

$$54{,}800\,\frac{(0.05 \times 1.5)}{2 + 1.5} = 1{,}175\ \text{Btu/lb.}$$

Note. The presence of sulfur in the fuel has a negligible effect on the chemical analyses of the flue gases.

The SO_2 is absorbed together with CO_2 and the error committed is as follows:

1 lb. of C generates 29.9 cu. ft. of CO_2

1 lb. of S generates 11.2 cu. ft. of SO_2

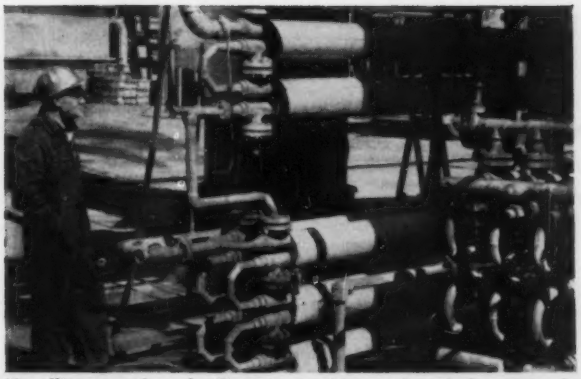
$$E = \frac{29.9\ C + 11.2\ S}{29.9\ C} = 1 + 0.375\ S/C$$

The S/C wt/wt ratio is generally below 0.025 which gives an error by excess of:

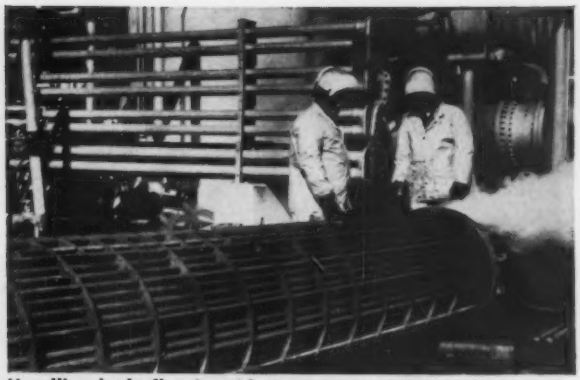
$0.375 \times 0.025 = 0.009375$ less than 0.01, that is less than 1 percent, and therefore negligible.

Nomenclature

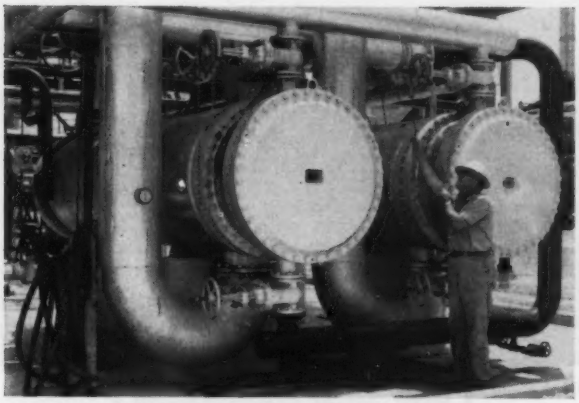
d = coefficient of air deficiency
$= -\frac{\text{Air used}}{\text{Air theoret.}}$
e = coefficient of excess air



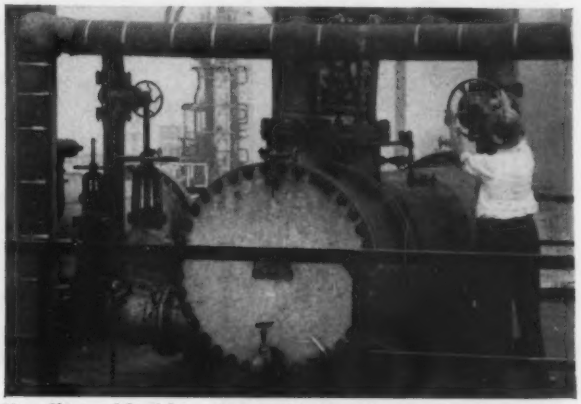
Handling caustic soda. Treatment with caustic soda is commonly employed to remove sulfur compounds and organic acids from petroleum. MONEL Alloy 400 tubing resists corrosive attack at the high temperatures involved in regenerating spent caustic soda.



Handling hydrofluoric acid. Concentrated HF is used as a catalyst in forming high octane gasoline from olefins and isobutane (HF alkylation). MONEL Alloy 400 tubing withstands corrosion by HF at all concentrations, in the temperature range existing in HF alkylation units.



Handling sulfides. MONEL Alloy 400 tubing is widely used in handling streams that contain corrosive sulfides, including hydrogen sulfide. This alloy is free from sulfide stress-corrosion cracking and hydrogen blistering. It is highly resistant to general attack and pitting by sulfides.



Handling chlorides. Hydrochloric acid may be formed by hydrolysis of chlorides in the crude petroleum. Some chlorides are likely to be present despite settling and desalting. MONEL Alloy 400 tubing has excellent resistance to chloride general attack and pitting and is immune to stress-corrosion cracking.

How MONEL® Alloy 400 stops tubing trouble that stops process streams

What tubing is best suited to handle corrosive process streams in today's refineries and petrochemical plants? What tubing can take today's higher processing pressures and temperatures?

Answer: MONEL* Alloy 400 tubing.

MONEL Alloy 400 (formerly designated MONEL alloy**) resists the corrosive attack of chlorides, hydrogen sulfide, caustics, sulfuric acid, fluorine and hydrogen fluoride.

The good heat transfer properties of MONEL Alloy 400 are expressed in these values for thermal conductivity:

Btu./sq. ft./hr./°F/in.	Cal./sq. cm/sec./°C/cm.
80-212°F . . . 180	27-100°C . . . 0.062
392°F . . . 188	200°C . . . 0.065
752°F . . . 215	400°C . . . 0.074
1112°F . . . 244	600°C . . . 0.084

High Strength – permits use of cost-saving, thin-wall tubes.

MONEL Alloy 400 has high ductility for easy rolling and bending . . . permits unannealed tube ends, tight-rolled joints, as well as hairpin bends.

MONEL Alloy 400 can be easily welded to steel tube sheets; fuses well to form a strong sound weld. Its coefficient of expansion is close to that of steel tube sheets, thus minimizing stresses and changes in shape with varying temperatures.

Long length tubing is available in lengths up to 85 feet. This enables designers to specify a longer heater of smaller diameter.

Be sure to keep MONEL Alloy 400 in mind when you design or retube heat exchangers and condensers. It is just one of the family of Huntington Alloys ready to serve the petroleum industry. For additional information, write for the booklet, "How Huntington Alloys Help to Raise Refinery Output and Lower Maintenance Costs."

*Registered trademark

**A new folder available on request lists all of the alloys available from the Huntington Division; gives data on the chemical composition of these alloys.

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MONEL® Alloy 400

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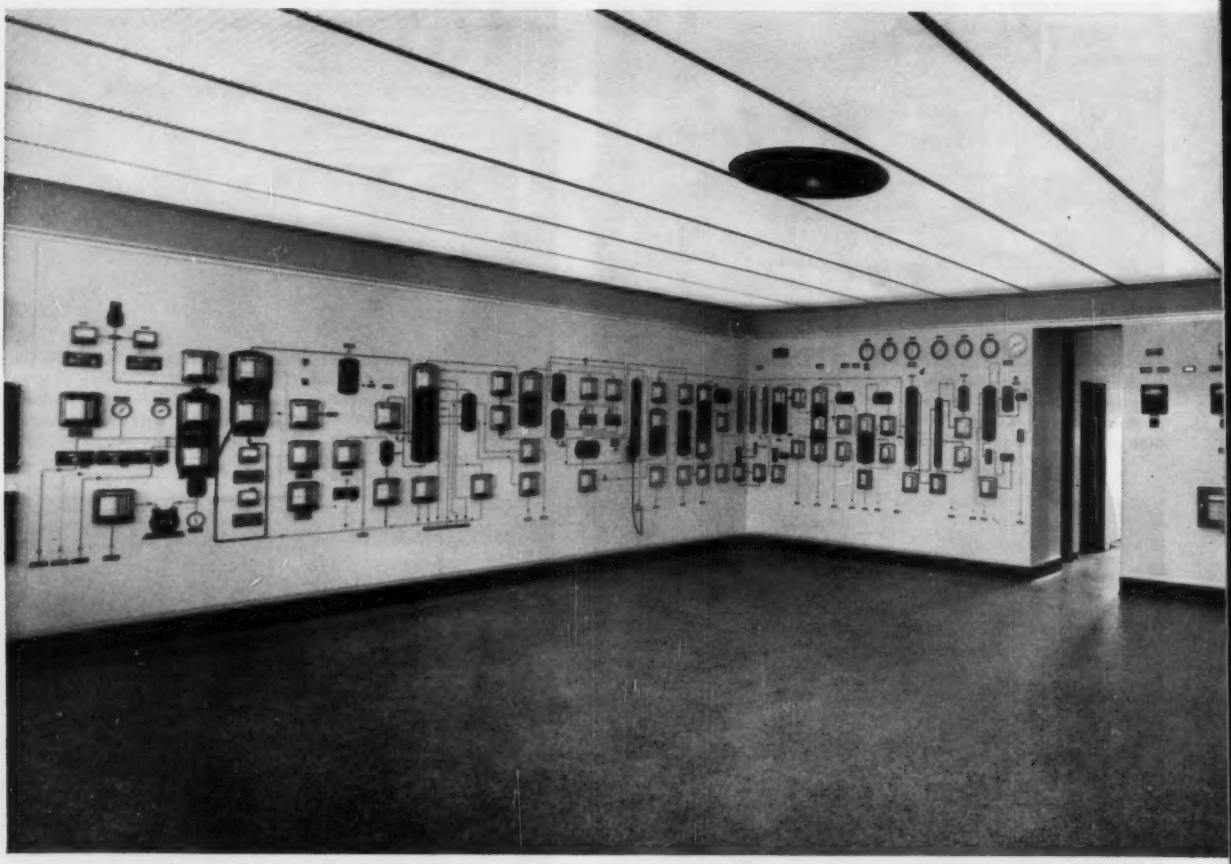
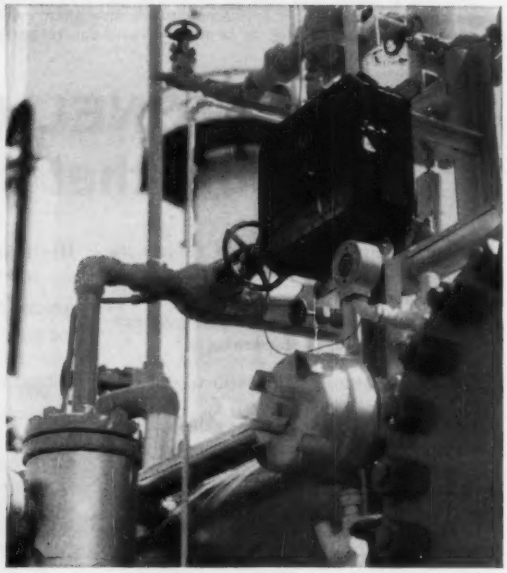


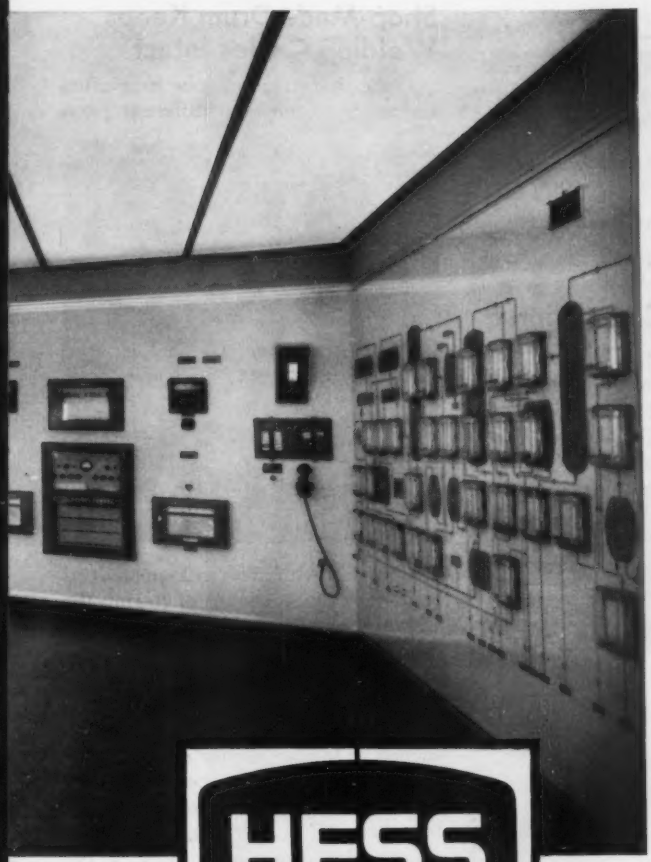
Taylor-built graphic panel at the new Hess refinery at Port Reading, New Jersey, showing some of the many 700 series TRANSCOPE® Recording Receivers and Controllers.

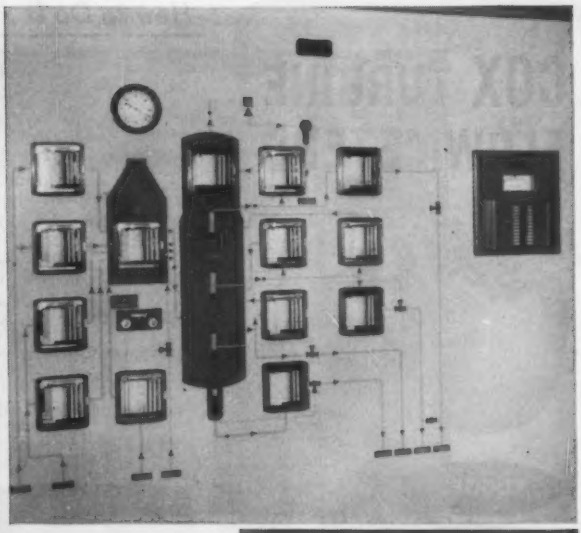
Fluid catalytic cracker section of main panel.



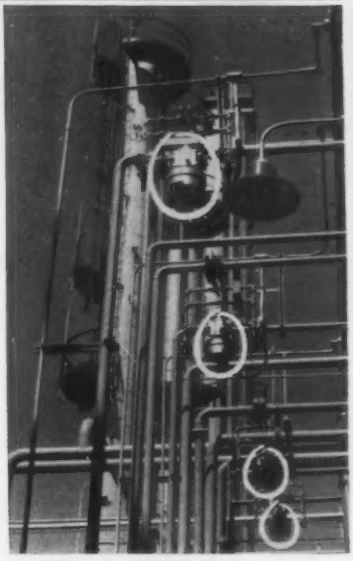
One of the many Taylor TRANSCOPE 726T series pressure transmitters.

Taylor Instruments





Control panel for vacuum crude unit is located in a separate room remote from main control panel.



Four of the Taylor TRANSCOPE 707 series flow transmitters on the alkylation unit.

HESS

CHOSE

TAYLOR FOR ELECTRONIC SUPERIORITY!

In selecting electronic controls for their ultra-modern refinery at Port Reading, N. J., Hess Inc. based their decision principally on four factors:

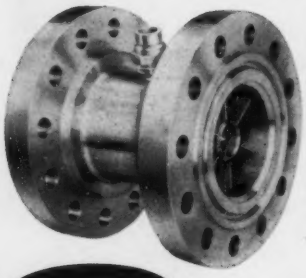
- *The quality of the instruments*
- *Systems capability of the supplier*
- *Supplier know-how in refinery applications*
- *Ability to deliver on time*

Based on these considerations Hess chose Taylor

The units, designed by U O P and engineered and constructed by Procon Incorporated employ more than 100 Taylor control loops. These include systems for the vacuum crude units, the fluid catalytic cracker, the gas concentration plant, the alkylation unit and various other treating units. Hess operating personnel were very pleased with the ease of start-up and subsequent on-stream performance of the instrumentation. For information on a Taylor electronic control system for your plant see your Taylor Field Engineer or write for **Bulletin 98335.** Taylor Instrument Companies, Rochester, N.Y., or Toronto, Ont.

MEAN ACCURACY FIRST

COX TURBINE FLOWMETERS



RUGGED

ACCURATE

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SERVICEABLE

Cox Turbine Flowmeters are gaining new acceptance with engineers and field meter men in refineries, pipelines and petro-chemical process plants as the "ideal" meter.

Here's why:

- *Low first cost*
- *Low maintenance*
- *Easy to install*
- *Readily replaces existing totalizing meters adding flow rate and control*
- *Sustained meter factor over wide range of products and flow rates*
- *Excellent repeatability*
- *Suitable for totalizing, recording, telemetry, control and blending applications*

For detailed information write for Handbook on Petroleum Measurement and Control Systems, Bulletin No. 4000.

COX INSTRUMENTS

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How to Do It . . .

$$= \frac{\text{Air supplied}}{\text{Air theoret.}} - 1 .$$

r = elementary chemical composition coefficient = 1 + H/4C.

H, C = number of hydrogen and carbon atoms in the fuel molecule, respectively.

L = heat loss, in Btu/lb.

Bend in Pipe Tong Speeds Joint Connection

Where short pipe lines need to be laid around the refinery, a pipe tong can be converted into a crank by putting a bend near the end of the

handle and using it as a crank when making up the joints. After the joint is connected the tong is applied and the pipefitter turns the crank and pulls the joint up tightly and quickly.

Shop-Made Drum Keeps Welding Cables Intact

On construction jobs it is often necessary to move to different parts

of the job with a truck-mounted welder. A simple means of storing the welding cables and hoses may be made by taking a piece of 12-inch pipe and placing a piece of 2½-inch pipe inside of it. The smaller pipe is placed on a bearing and a crank attached to the outside for easy turning.

When the job is reached, the cables and hoses are easily unwound by pulling them off the drums. When it is time to leave, a simple turn of the crank will pull the cables and cords back out of the weather and away from damage. When the truck is moved only a short distance, the cables can be hung over a hook on the end of the drums.

Pipe Nipples Cleaned With Abrasive Cloth Rope

In removing and relocating a number of station control instruments, ex-

$$ Your Ideas Are Valuable! $$

At least $10.00 will be paid for each idea accepted for "How to Do It." All you need to do is write a brief note telling about your idea, then attach a photo or sketch (if needed), and mail it to Editor, Hydrocarbon Processing & Petroleum Refiner, P. O. Box 2608, Houston.

Like any original . . . it cannot be duplicated!

Regardless of claims, *there's only one* TARSET® . . . the *original* coal tar-epoxy resin coating. No other coal tar-epoxy resin coating duplicates the TARSET formula, and it has not been made available to any other coating manufacturer. No other coal tar-epoxy coating combines the proven adhesion characteristics, chemical resistance and low moisture absorption properties of coal tar pitch with the hardness, ruggedness and chemical resistance characteristics of epoxy resins, like Pitt Chem TARSET.

Here are a few advantages of TARSET over other coatings of its type:

1. **Only TARSET is backed with a six-year service record.**
2. **Only TARSET has established so outstanding a performance record.**
3. **Only TARSET is approved by governmental and industrial agencies.**

If you have a corrosion problem that seems unsolvable, investigate TARSET's proven advantages. Contact your nearest Pitt Chem Industrial Distributor . . . he's listed in the "Yellow Pages."

3279

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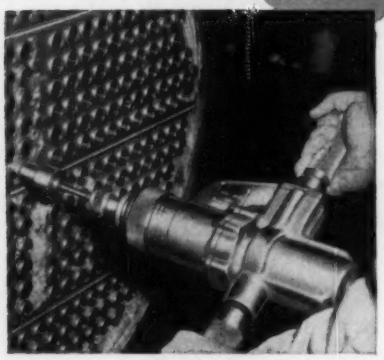

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Lightweight cleaners for tubes up to 1" O.D. Outside mounted motors for larger tubes . . . all with built-in flushing systems.

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Air-powered motors and cleaner heads for high-speed internal cleaning of tubes.

NEW
AIR-POWERED
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Grooves tube sheet holes so tubes can be locked in position as they are rolled.
NEW
PNEUMATIC
LIGHTWEIGHT
SCALER
For scaling, peening, beading and star drilling. Fast rust, weld splatter and paint removal. 11" long, weight—4 pounds. Operator accurately controls blows per minute from a few up to 4600.

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AIRETOOL
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How to Do It . . .

amination of the short, ½-inch nipples carrying the flow revealed their inner surfaces were pitted and otherwise slightly roughened.

The conventional remedy would be to replace the piping, which would have meant a lengthy job of removing and replacing couplings, connections, etc.

Instead, strips of abrasive cloth were interwoven between strands in rope. The strands are spread open by giving the rope a reverse twist. The abrasive strips were threaded between the strands, with the coated side of the abrasive out. Releasing the rope closes the strands, holding the strips firmly.

The combination rope-abrasive was then seesawed through each nipple, quickly producing a super-smooth inner surface.

Idea by Harvey Miller, Danboro, Pa.

Reader's Comment:

To cure a crooked nipple, *don't* cut a crooked thread.

The August 1961 "How to Do It" section contained an item suggesting a cure for misaligned socket by cutting an offset thread on the nipple. This is dangerous, as the pipe wall will be weakened on the side where the dies cut deepest. A case occurred in England recently where a nipple, so weakened, gave way and showered an instrument man with hot asphalt, killing him. (The man was standing on the pipe—another dangerous practice.)

The correct way to solve this problem is either to re-align the socket or, having cut a true thread on the pipe, to screw it in, note the direction of misalignment of the pipe, unscrew it and bend it gently until the far end will be true when it is replaced. *Don't* bend the pipe while screwed in the socket, or here again local weakening of the pipe wall may occur.

Ed. Note: Thanks to alert reader G. M. Powell, E.R.P.I., Paris, France, for this comment.

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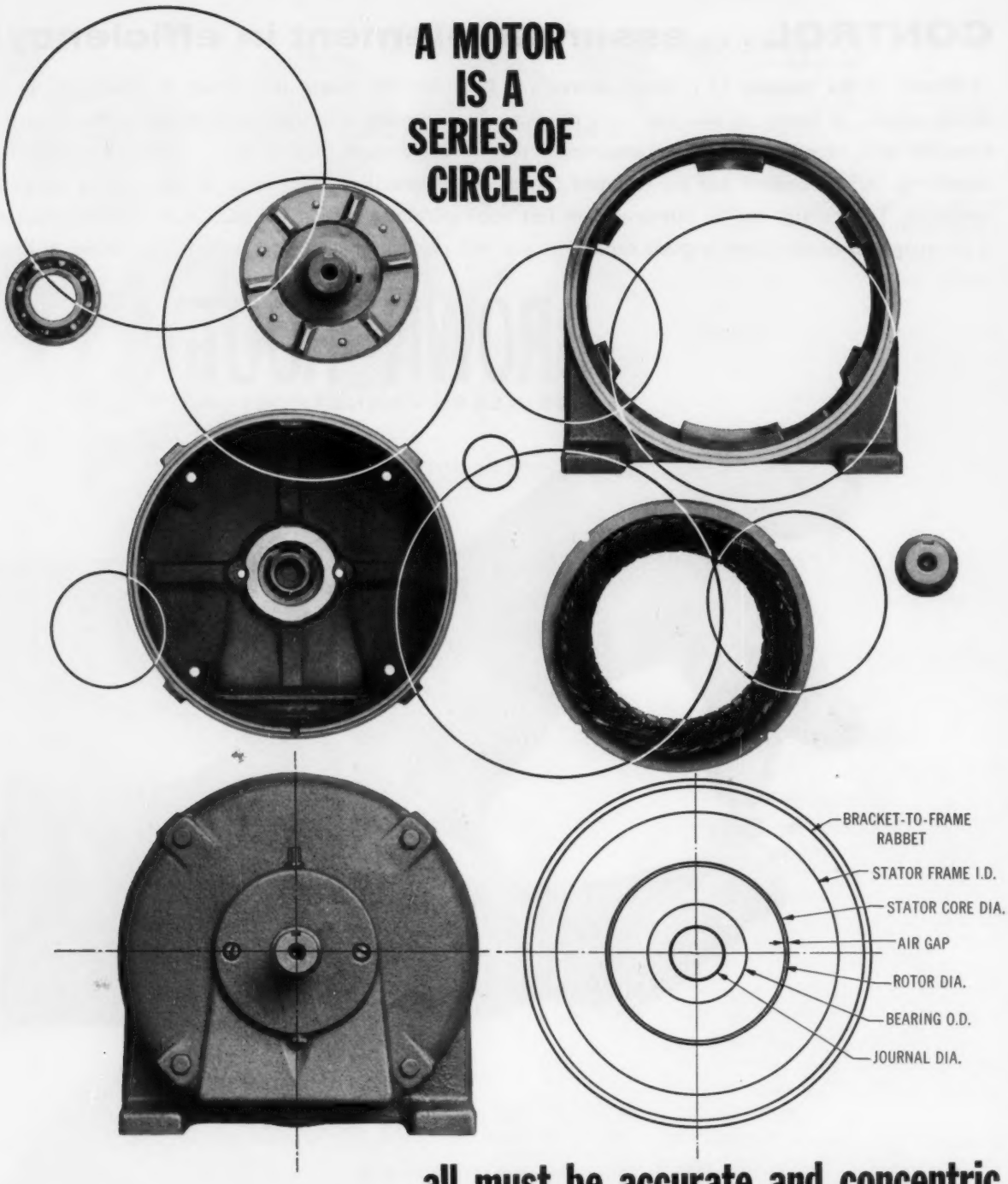
A MOTOR IS A SERIES OF CIRCLES



all must be accurate and concentric

In manufacturing Elliott Crocker-Wheeler motors, a dozen critical "circles" are formed accurately and concentrically through unique and extraordinarily precise production methods. The result is exact alignment of all parts, true and uniform air gap, free-spinning rotor, quiet, cool, dependable operation.

■ *Elliott Crocker-Wheeler integral-hp a-c and d-c motors—from smallest to largest—are offered in all conventional enclosures and modifications; with insulation to suit the application, including* EPA-SEAL *epoxy insulation for use where conditions are most severe.* WI-3

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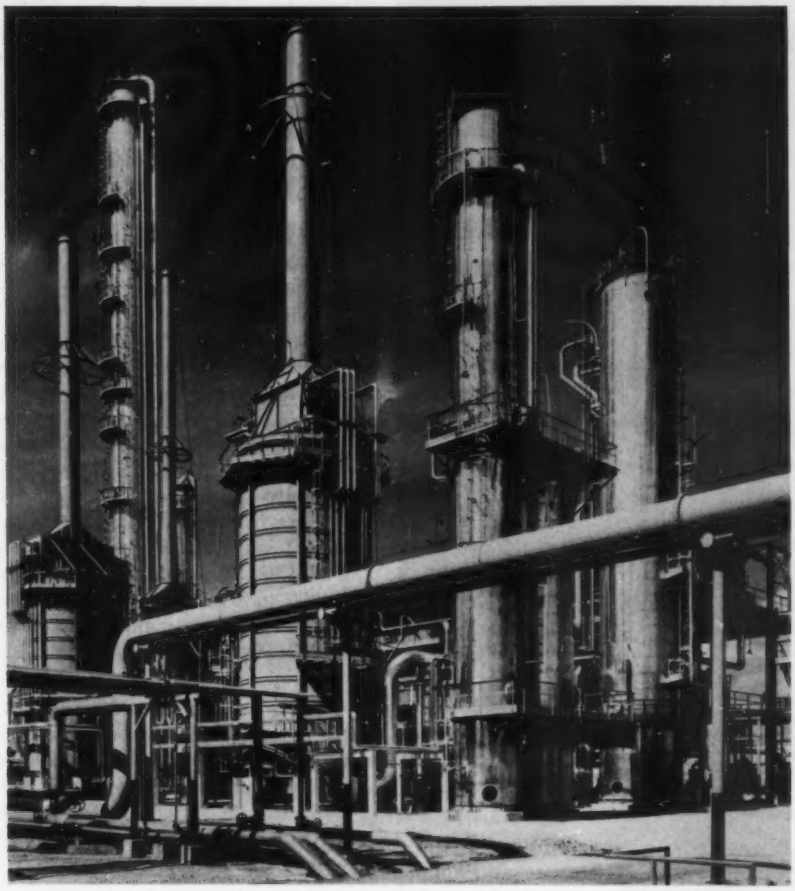
Who's Building in HPI...



Newest addition to the skyline in the growing petroleum refining and chemical complex at Lake Charles, La., is this striking petrochemical plant at the Cities Service refinery. Plant produces 120 million pounds per year of high-purity orthoxylene.

The Atlantic Refining Co. has awarded a construction contract to Catalytic Construction Co. for an increase of capacity at Atlantic's alkylation unit at the Point Breeze refinery, Philadelphia. The work, which is planned to expand the unit from 5,500 to 7,500 bpd, is expected to begin in mid October this year.

Great Northern Oil Co. plans to step up gasoline production at its Pine Bend, Minn., refining operation. Procon, Inc., has been awarded the contract for the work, which will cost over $1 million. Current crude throughput at the plant averages about 39,000 bpd.

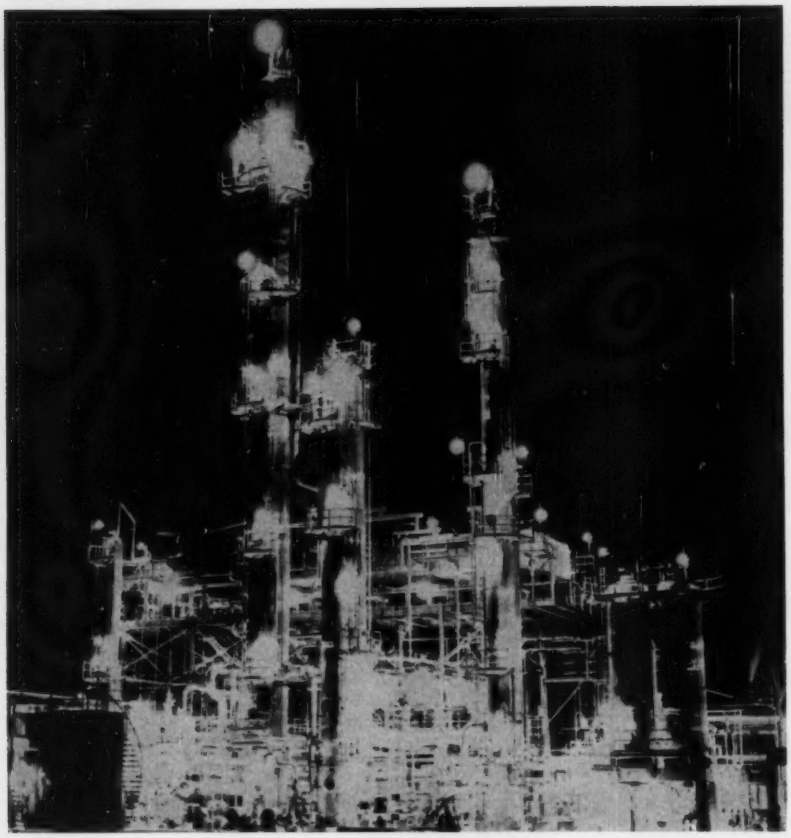
Nalco Chemical Co. has started building its alkyl lead plant in Freeport, Texas, to be the firm's largest manufacturing facility. The unit, which will be of the open-air petrochemical type, will cover approximately one half of the company's 25-acre site. (HYDROCARBON PROCESSING & PETROLEUM REFINER, June 1961, Page 237.)

DX Sunray Oil Co. has placed a crude oil distillation unit with electronic computer control incorporated in the original design on stream at its Tulsa, Okla., refinery. The company claims this to be the first such unit in the United States to be put in operation with computer control. The facility has an 85,000-bpd capacity and is a three-stage distillation processing operation. Replacing five other units which had a combined capacity of 75,000 bpd, the new unit produces straight run gasoline, naphtha, kerosine, heating oils, lubricating oil and wax base stocks, asphalts and cracking stocks.

Texaco, Inc., will build one of the largest naphthalene plants in the world at its Port Arthur, Texas, refinery. The multi-million-dollar plant, with a production design capacity of 100 million pounds of petroleum-derived naphthalene per year, will go on stream by or before 1963.

Continental Oil Co. plans to construct a natural gasoline plant in the Sacatosa field, Maverick County, Texas. Construction of the plant, which will be located on the N. J. Chittim lease, will start immediately, with completion expected by March 1962. The facility will have a daily processing capacity of 2.5 MMcf of gas and will produce some 18,000 gallons of propane, butane and gasoline. The construction contract has been awarded Delta Engineering, Houston.

Building . . .



Nighttime Operation

Glowing under bright lights, Phillips Petroleum Co.'s new UOP Udex unit works on through the night producing 15,000 bpd of benzene at Phillips' Sweeny, Texas, refinery.

Banquete Gas Co., a division of Crestmont Consolidated Corp., has started construction of a gasoline treating plant in Goliad County, Texas. The plant is being built in partnership with Houston Natural Gas Production Co. It is designed to extract 9,600 gallons of natural gasoline, butane and propane per day from a throughput of approximately 10 MMcf of natural gas. Cost of the plant, which is expected to be completed in December of this year, is approximately $250,000.

Cities Service Co. will construct a large petrochemical manufacturing plant at its East Chicago, Ind., refinery. The plant will manufacture high-purity naphthalene and will have an initial design capacity of 50 million pounds per year. It is reported to be the first petroleum naphthalene manufacting unit in the Midwest, and is scheduled for completion in mid 1962. The plant will convert middle distillate feedstocks into naphthalene, a petrochemical intermediate used in making a wide variety of products, including plasticizers, alkyd resins, dyestuffs and insecticides.

Skelly Oil Co. and Swift & Co. are joining in a nitrogen products plant venture in Iowa. The two firms each own 50 percent of a new company, Hawkeye Chemical, which will build and operate the facility near Clinton. The plant, to cost over $10 million, will produce about 30 tons per day of ammonia, nitric acid, nitrate solution, ammonium nitrate, nitrogen solutions and urea.

Cary Chemicals, Inc., has awarded a $4-million contract to Blaw-Knox Co., Pittsburgh, for the design and construction of a 100-million-pound-per-year polyvinyl chloride plant in Burlington Township, just west of Burlington, N. J. Plans call for the first 50-million-pound unit to be on stream within nine and a half months. Construction of the second 50-million-pound plant will be started within 12 months. The project is part of Cary's $14-million expansion program.

Shell Oil Co. has received a resolution from Newcastle County Levy Court in Delaware rezoning 2,672 acres of the 3,345-acre Blackbird Hundred tract where Shell plans to build an $80-million refinery. The resolution gives Shell everything it requested except rezoning on 673 acres.

Monsanto Chemical Co. will construct an ammonia plant at Muscatine, Iowa, to go on stream in the fall of 1962. The plant, to manufacture 200 tons per day, is near an anhydrous ammonia terminal Monsanto is building to handle 15,000 tons.

E. I. du Pont de Nemours & Co., Inc., is constructing a vinyl fluoride monomer plant at Louisville, Ky., to cost over $3 million. The plant's production will be centered on shipments to Buffalo, N.Y., for use in Du Pont's new polyvinyl fluoride film.

Allied Chemical Corp. has completed expansion of another stage in its polyethylene production program at Orange, Texas. The new facilities will approximately double capacity. The first polyethylene unit at Orange went on stream early in 1960 and adjoins an ethylene derivative plant operated by the company's Nitrogen Division.

AviSun Corp. claims to be the world's largest producer of polypropylene with its new plant on stream at New Castle, Del. AviSun has a total polypropylene capacity of 125 million tons, compared to a large second contender, Hercules Powder Co.

Helex Co., which received the U.S. Interior Department's first contract for helium conservation, will build a helium extraction plant at Bushton, Kan., to extract 700 MMcf of helium annually. Helex, which expects to do

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

New Shawinigan process lowers production cost of hydrogen cyanide

A new hydrogen cyanide process, developed by Shawinigan Chemicals Ltd. of Canada and available through The Lummus Company, produces HCN from ammonia and hydrocarbon (methane or propane) in a non-catalytic, oxygen-free reaction. The process – first commercial application of the "FLUOHMIC"* reactor – offers low production costs and ease of operation.

Yields on hydrocarbon and ammonia exceed 85% with negligible undecomposed ammonia carry-through, simplifying recovery or disposal requirements. Furthermore, valuable high-purity hydrogen by-product is available for use as required.

The Shawinigan HCN process produces hydrogen cyanide competitively using 8 mill power and 25-30¢ per MSCF natural gas. It becomes increasingly attractive in areas of lower power costs or higher cost hydrocarbon. A commercial scale reactor is being operated by Shawinigan Chemicals Ltd.

How the Process Works

The reaction system uses a uniquely designed fluidized bed reactor to realize the efficiencies of a very high temperature in the hydrogen cyanide reaction.

The Shawinigan HCN reactor consists of a refractory lined electrically heated vessel. It operates in the range of 2,400 to 3,000° F. at essentially atmospheric pressure. A non-consumed fluidized bed of coke particles is heated by electrical conduction. The reactor design achieves an extremely uniform high temperature throughout the reaction zone. At these very high temperatures the significant improvement in conversion rates – compared with conventional processing – results in a high concentration of product in the effluent gas. The effluent gas is cooled and purified by standard methods.

Process Advantages

Some major advantages of this process are: (1) Absence of water from the effluent gas. This eliminates the problem of tarry polymer formation in the cooling and recovery section. (2) Considerable reduction in unreacted ammonia in the effluent gas. This eliminates the problem of recovery or disposal of unreacted ammonia. A typical carry-through ammonia content would be 0.3 volume % on net reactor effluent. (3) Greatly reduced stringency in feed-stock purity requirements. This is a natural result of the elimination of catalysts from the process. (4) Flexibility in choice of hydrocarbon feed. L.P.G. can be used where natural gas supply is unavailable or interruptible. (5) Operating rates are flexible. Units will perform well at rates as low as 25% of capacity. (6) High concentration of HCN in the reactor effluent. This may be 5-6 times as high as in present commercial processes.

View of the Hydrogen Cyanide Reactor in operation at The Shawinigan Chemicals Limited Cyanide Plant.

For further details on this process, contact your nearest Lummus office.

*Trademark – Shawinigan Chemicals Limited

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, New York, Houston, Washington, D. C., Montreal, London, Paris, The Hague, Madrid; Engineering Development Center: Newark, N. J.

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Building . . .

$9.5 million worth of helium business with the government each year, is a subsidiary of Northern Natural Gas Co., Omaha, Neb.

Lavaca Gas Processing Corp. expects to complete construction soon on a gas processing plant near Halletsville, Texas. The facility, which will cost $750,000 will produce propane, butane, natural gasoline and stabilized condensate.

Ott Chemical Co., Muskegon, Mich., plans to expand its specialty isocyanates capacity by 200 percent. Current output of substituted aryl monoisocyanates for Ott Chemical will be supplemented by aliphatics, ethyl and methyl isocyanates.

Cooperative Farm Chemicals Association has engaged Chemical Construction Corp to design and construct a nitric acid plant at Lawrence, Kan. The new facility will produce 120 tons per day.

Wallace & Tiernan, Inc., Buffalo, N.Y., has joined Yoshitomi Pharmaceutical Industries, Ltd., Osaka, Japan, to make catalysts for high-pressure polyethylene. A joint subsidiary will be set up to build and operate a plant.

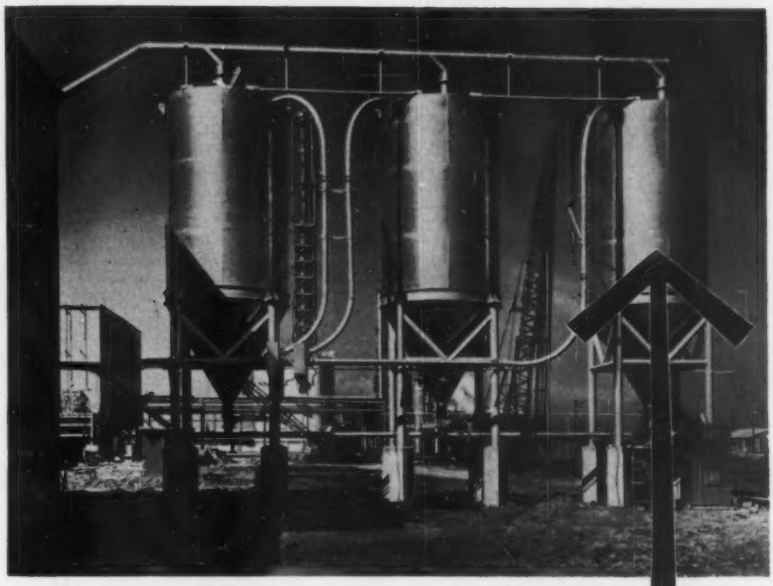
Allied Chemical Corp. will place its Ironton, Ohio, ammonia plant under control of a digital computer before the end of this year. This plant, operated by Allied's Nitrogen Division, is the largest ammonia plant to use computer control, according to Thompson Ramo Wooldridge, Inc., supplier of the computer. Initially, the computer will be used for closed-loop control of the most important areas of the ammonia plant. It will also log plant operating data so that on-line control can be extended to other plant areas.

Shell Oil Co. has awarded a contract to The Fluor Corp. for installation of two hydrotreating units at its Anacortes, Wash., refinery. Total capacity will be 25,000 bpd.

Tidewater Oil Co. and Collier Carbon & Chemical Co. will have an information and computer system installed at their naphthalene plant,

from ALCOA

good designs made better with aluminum



Metal Arts Co. eliminated product contamination in bins and piping at Koppers polyethylene plant

Originally selected for initial low cost, aluminum proved a good design specification for bins and conveyor piping at the Koppers plant, Port Arthur, Texas. Used in polyethylene production, these units have eliminated undesirable metallic contamination of the product — thanks to the chemical stability of aluminum. Bins were designed and fabricated by Metal Arts Co., Houston. Here, again, is a case in point showing a good design made still better by the valuable chemical and physical properties of ALCOA® Aluminum. The coupon will bring you detailed information on how to make improvements in your own good designs.

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- ☐ 68-10460 Process Industries Applications of Alcoa Aluminum
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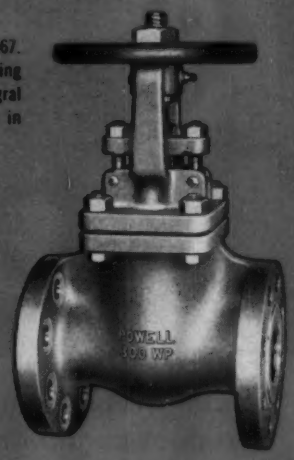
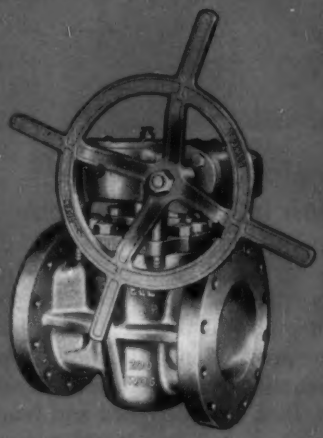
This truly dependable performance results from many things—among them Powell's engineering know-how, accumulated during 115 years of valve manufacturing . . . and skillful use of the widest selection of quality materials—bronze, iron, steel and alloys.

Then, too, you can count on getting the Powell Valve you need, when you need it. That's because Powell maintains a network of distributors backed up by factory inventories, warehoused "ready to go."

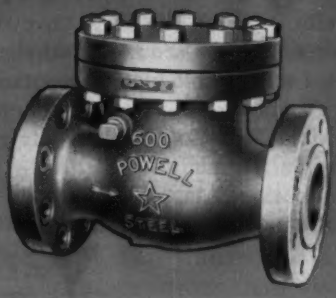
Get the full story from your nearby Powell Valve Distributor, or write us direct.

300-pound Stainless Steel Gate Valve—Fig. 2467. Bolted flanged yoke-bonnet. Outside screw rising stem. Fully guided solid or split wedges, integral seats. Sizes, ½" through 2". Also designed in larger sizes, 2½" through 12".



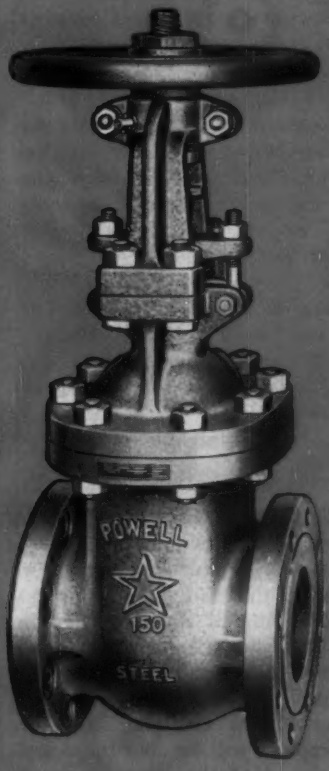


200-pound W.O.G. Semi-Steel Lubricated Plug Valve—Fig. 2207G. Bolted gland type. Worm gear operated. Sizes, 4" through 12". Also available with spur gearing.



600-pound Steel Horizontal Swing Check Valve—Fig. 6061, flanged ends. Bolted cap. Renewable disc and seat rings. Has full flow area when valve is fully open. Sizes, ½" through 8".

Refer to our catalog in Chemical Engineering Catalog.



150-pound Steel Gate Valve —Fig. 1503, flanged ends. Bolted flanged yoke-bonnet. Outside screw rising stem. Interchangeable solid or split wedges, renewable seats. Sizes, ¼" through 30".

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Building . . .

Delaware City, Del. The system, an ISI unit, is believed to be the first such facility to be installed in a U.S. naphthalene plant. It will scan 300 temperatures, pressures, flows and fluid levels with an expansion capability to 500 points. Catalytic Construction Co. will handle installation.

Cities Service Petroleum Co. will build a natural gasoline plant in Calhoun County, Texas, approximately four miles northeast of Seadrift. The plant will be of the refrigeration-absorption type. It is designed to process 10 MMcfd of gas from the North San Antonio Bay field. The plant will produce a natural gasoline-butane-propane mix. Contract for construction of the plant has been let to Austin Rankin Corp. of Houston. Construction start is scheduled sometime this month, with initial operation expected in December.

Collier Carbon and Chemical Corp. has started operating a new sulfuric acid plant adjacent to Union Oil Co. of California's Los Angeles refinery. The plant converts 250 tons per day of refinery waste products into sulfuric acid.

H. L. Hunt Interests has awarded a construction contract to O. L. Olsen & Co., Houston, for a 12-MMcfd, absorption-refrigeration-type gas processing plant at McGregor, N. D.

Copolymer Rubber & Chemical Corp. is nearing completion on its butadiene expansion project at Baton Rouge, La. The $5-million investment increases the company's butadiene capacity by 50 percent.

Tidewater Oil Co. plans to build a gas processing plant in the Normanna field of Bee County, Texas. Tidewater and Dougherty Estates will own the plant, which will have a processing capacity of about 30 MMcfd of gas and will produce about 1,200 barrels of products daily.

Diamond Alkali Co. has placed a chloromethane unit on stream at Belle, W. Va., making methyl chloride, chloroform and hydrochloric acid.

Humble Oil & Refining Co. has completed an expansion of butyl rub-

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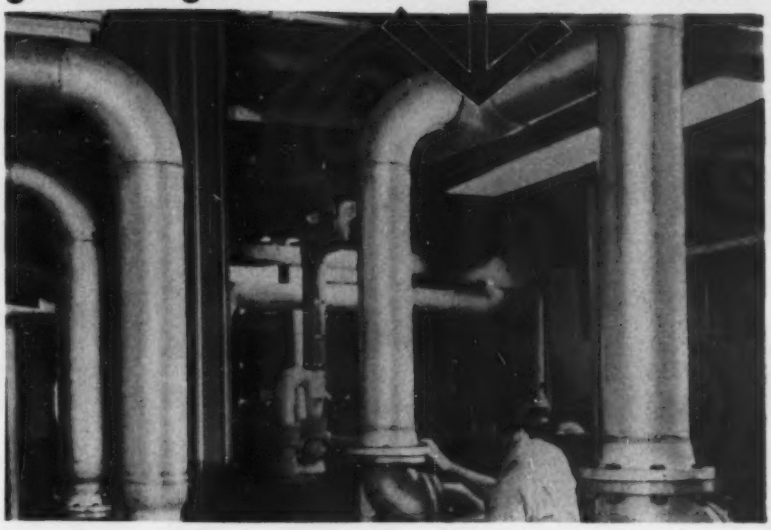

All-aluminum cooling system reduces danger of water contamination in Brookhaven's new Synchrotron

More than one mile of aluminum piping and some 2,600 FLOWLINE aluminum fittings comprise the magnet cooling system at Brookhaven National Laboratory's new Alternating Gradient Synchrotron. High-purity water at 65°F is circulated through an aluminum piping system to cool electromagnets arranged in a one-half mile long circular ring; the water is then returned to heat exchangers. Because the conductivity of the water must be kept below 11 micromhos, aluminum was selected for its superior resistance to corrosion. View of pump room above shows sections of aluminum piping; FLOWLINE tees, elbows, and reducers, made with ALCOA® Aluminum by Flowline Corp., New Castle, Pa. For more information about aluminum's applications and versatility, please send the coupon.

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- ☐ 68-10460 Process Industries Applications of Alcoa Aluminum
- ☐ 88-11453 Solving Refinery Corrosion Problems with Aluminum

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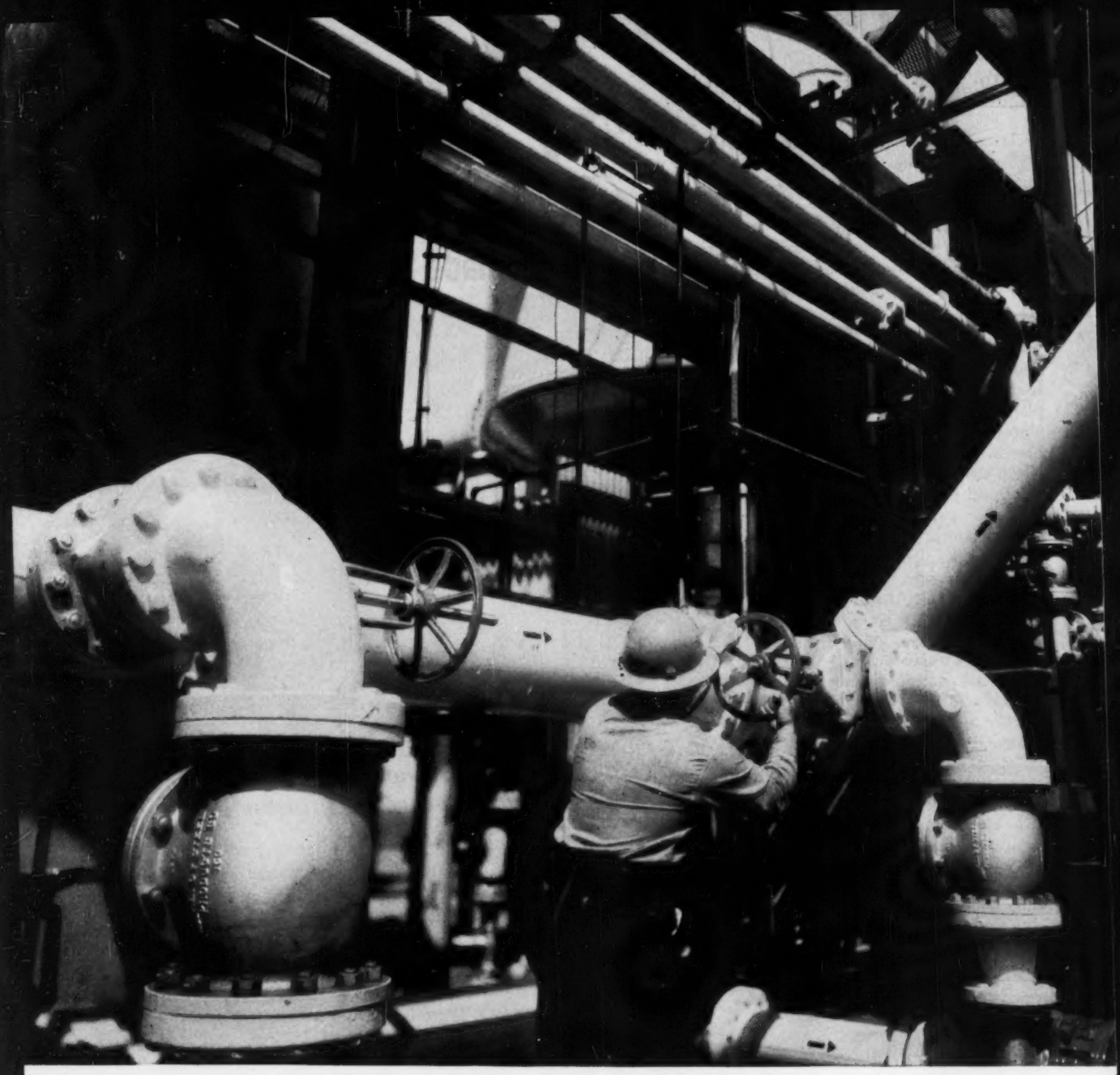

Trouble-free valve performance for 3rd straight year in 98% acid service

These Aloyco valves control the flow of 98% Sulfuric Acid at the three-year-old plant of General Chemical Division, Allied Chemical Corporation at Elizabeth, New Jersey.

They are made from Aloyco 20, a stainless alloy of exceptional versatility. Resistant to a broad range of acids as well as alkalies, valves in this material as produced by Aloyco are first choice in processing plants across the nation.

When you have a corrosive or contamination problem—remember Alloy Steel Products Co. We specialize in Stainless Steel Valves exclusively. Call our local representatives or write us at 1303 West Elizabeth Avenue, Linden, New Jersey. 1.1

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Building . . .

ber capacity at its Baton Rouge, La., plant. The company is also building a plant to produce a new oxo alcohol for application in vinyl plastic articles.

Mitsubishi Oil Co. plans to build units at Mizushima, Okayama, Japan, as part of a petrochemical complex. Units and capacities are: Acetaldehyde, 63,200 tons yearly; ethylene, 43,100 tons; propylene, 33,200 tons; acrylonitrile, 7,200 tons; acetone, 15,000 tons; octanol, 6,000 tons. Mitsubishi will erect a 200,000-bpd crude refinery to provide feed stocks for the complex, which is to be completed by January 1964.

Refineria Panama S.A. is building a refinery on the island of Payardi, near Colon, Panama. Scheduled for completion by December, the plant will cost $30 million. Refineria Panama is a joint subsidiary of Continental Oil Co. and National Bulk Carriers, Inc.

Gas & Fuel Corp., Melbourne, Australia, will expand its high-pressure gasification facilities at Morwell, Victoria. Increases include production of fertilizers and other by-products and high-grade motor oil, presently at 600,000 gallons per year.

Iraq is making progress in its plan to build an export refinery on the Persian Gulf. The proposed $42-million plant will have a yearly capacity of 50,000 bpd. Ente Nazionale Idrocarburi technicians are advising the Iraqi government.

Maruzen Oil Co., a Japanese independent, has been invited to build a petrochemical plant in Singapore by the Singapore government. Maruzen is currently building a 20,000-bpd refinery with Toyo Menka, a Japanese trading firm, in Singapore. The refinery is expected to be in operation by the end of this year.

Spain has authorized Calvo Sotelo, state-controlled firm, to set up a refining complex at Puertollano. A pipe line is planned to supply a new 22,000-crude still at Puertollano.

Shawinigan Chemicals, Ltd., who will build a petrochemicals plant at Varennes, Que., has announced that

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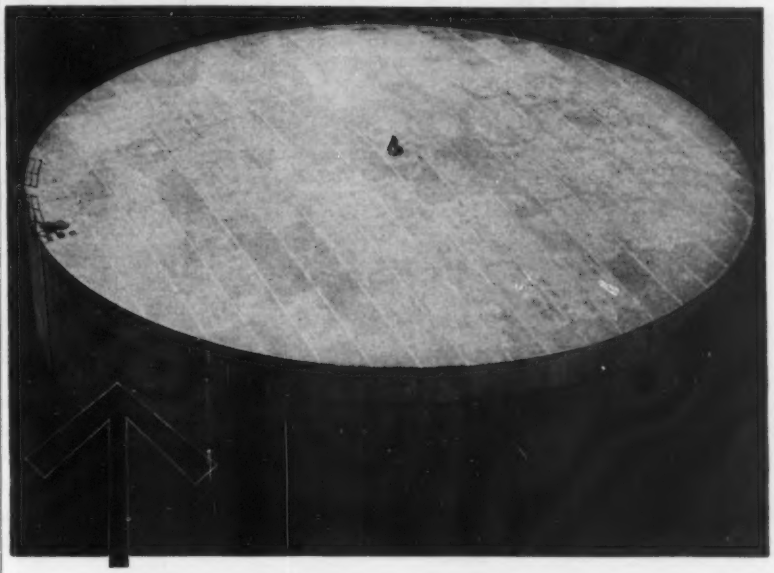
good designs made better with aluminum



ensures uninterrupted storage of 83% ammonium nitrate at 180°F for Armour Agricultural Chemical Co.

Here you see the world's largest all-aluminum storage tank. Field-erected by Chicago Bridge & Iron Co. at the Selma, Mo., plant of Armour Agricultural Chemical Co., it holds ammonium nitrate at 180°F with minimum down time recorded since 1955. The reason for this is the unmatched ability of aluminum to resist the corrosive attack of the stored solution — and the surrounding atmosphere, as well. 26 ft high and 128 ft in diameter, the tank represents one more good design made still better by the matchless qualities of aluminum. Mail the coupon and discover how you can improve your own good designs with ALCOA® Aluminum.

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- ☐ 68-10460 Process Industries Applications of Alcoa Aluminum
- ☐ 50-19415 Welding Alcoa Aluminum
- ☐ 02-19051 Alcoa Aluminum Handbook
- ☐ 42-20849 Resistance of Aluminum Alloys to Weathering and Resistance of Aluminum Alloys to Chemically Contaminated Atmospheres

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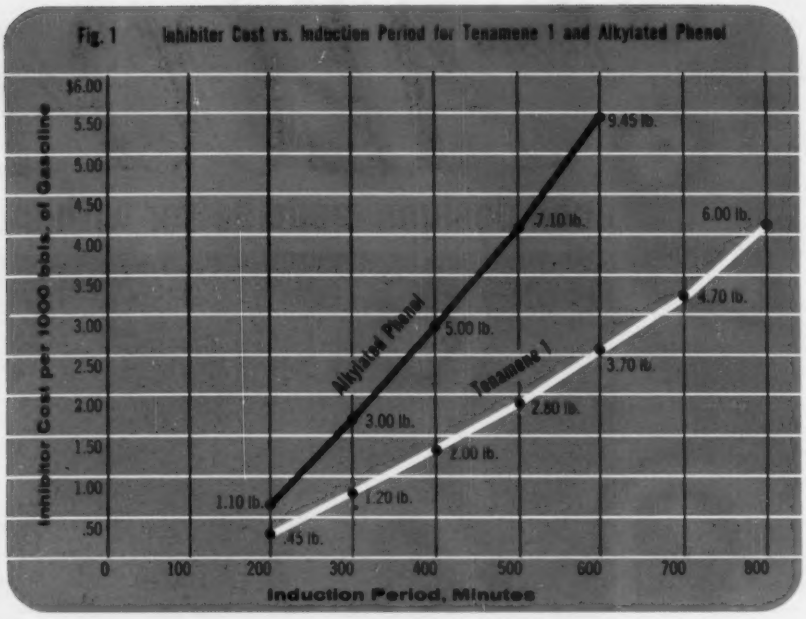


Gum inhibitor costs getting too high? Tenamene 1 keeps them down —without sacrificing gasoline stability

When you come right down to stability vs. cost, Tenamene 1 antioxidant at 69 cents a pound is often the least expensive gum inhibitor for many unsaturated, thermally or catalytically cracked stocks.

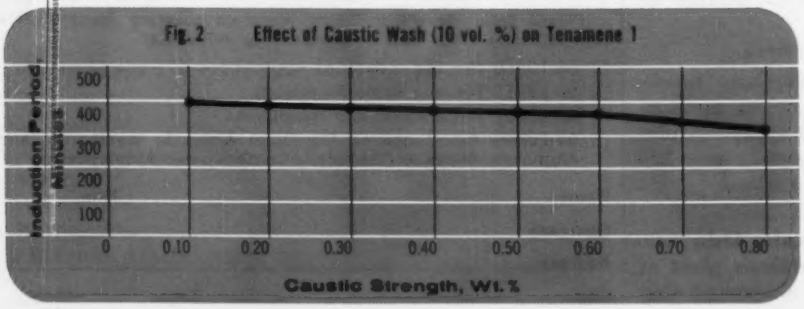
Compared with alkylated phenol inhibitors for instance, Tenamene 1 —an aminophenol in isopropyl alcohol—offers refiners considerably lower treating costs because of its higher potency. Fig. 1 indicates the savings possible in a leaded premium gasoline recently tested, even though the alkylated phenol (flake) inhibitor is priced at 57 cents a pound.

Although Tenamene 1 is caustic-soluble, this becomes a factor only when the inhibited gasoline is in contact with a solution exceeding 0.4% caustic. Most refiners who guard against caustic entrainment have no trouble in this respect. The effect of caustic concentration on induction period is indicated in Fig. 2.

Detailed performance data on Tenamene inhibitors can be quickly obtained through an Eastman representative. Call any of the sales offices listed here, or write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

Tenamene® 1
an Eastman gasoline additive

SALES OFFICES: Eastman Chemical Products, Inc., Kingsport, Tennessee; Atlanta; Boston; Buffalo; Chicago; Cincinnati; Cleveland; Detroit; Greensboro, N. C.; Houston; Kansas City, Mo.; New York City; Philadelphia; St. Louis. **Western Sales Representative: Wilson & Geo. Meyer & Company,** San Francisco; Denver; Los Angeles; Phoenix; Salt Lake City; Seattle.



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Building . . .

feed stocks for the plant will come from British American Oil Co., Ltd., British-American has a 25-percent interest in Shawinigan Chemicals. (HYDROCARBON PROCESSSING AND PETROLEUM REFINER, August 1961, Page 166.)

Shell Oil Co. plans to place a $6-million plant on stream in January to produce synthetic organic acids at its Pernis chemical works in the Netherlands. End use of the acids: Surface coatings, plastics, rubber and metallurgical industries.

National Oil Co. of Libya is considering plans to refine and market petroleum products in Libya. The company was formed by U.S. independents, U.S. and foreign cooperatives and Libyan interests.

Houdry Process Corp. of Philadelphia and Compagnia Internazionale Generale Industriale—Malatesta, S.p.A., (CIGI) have formed an equally owned company to manufacture and sell polyurethane foam and foam products. The new firm, Montecassino, S.p.A., is located in Cassino, Italy. Manufacturing operations in the Southern Italy city are expected to be underway late this year.

Proizvodnja Nafte has awarded a contract to Societe Belge de L'Azote et des Produits Chimiques du Marly (SBA) for the construction of a natural gas plant in Yugoslavia. The gas will be used in producing methanol.

Ammonia S.A. has given Societe Belge de L'Azote et des Produits Chimiques du Marly (SBA) a contract for the construction of an ammonium nitrate plant. The facility, to be incorporated in the Wingles plant of Ammonia S.A. at Pas-de-Calais, France, will have a daily capacity of 150 tons.

Arabian Oil Co. of Japan plans to construct three refineries in Japan to have a combined capacity of over 200,000 bpd. The plants, to go on stream in 1963, 1964 and 1965, will be outlets for Arabian Oil's Khafji crude production on the Persian Gulf. The three plants:

- At Numazu—100,000-bpd refin-

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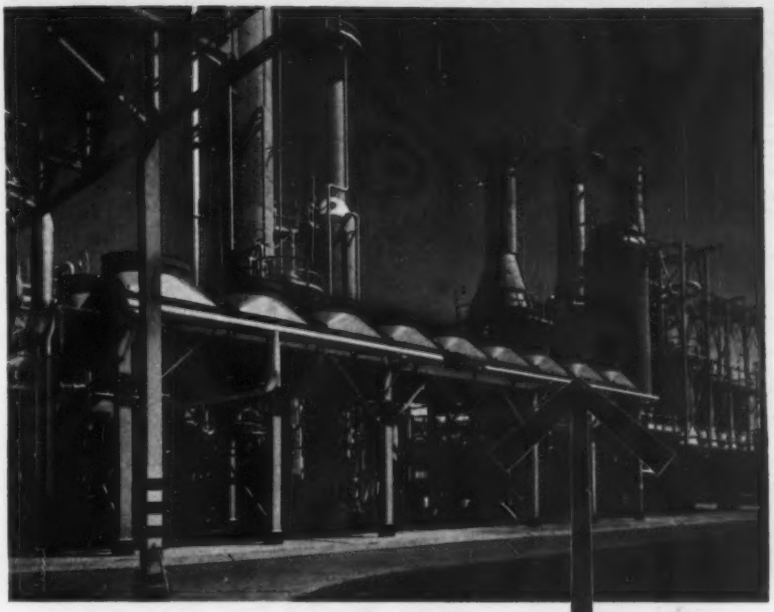
good designs made better with aluminum



improves process cooling rate, resists corrosion at Southwestern Oil & Refining Company's Big Texas Refinery

Aluminum's superior ability to transfer heat finds practical employment in this Solo-aire cooling installation, made with ALCOA® Aluminum by Hudson Engineering Corporation, Houston, Texas. Light, bright aluminum has other advantages here: notable corrosion resistance and remarkable low-temperature properties. Installed at Corpus Christi, Solo-aire is clear evidence of another good design made better with aluminum. Perhaps ALCOA can help improve your good designs. For more information, please mail the coupon.

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- ☐ 34-20437 Aluminum Alloy Heat Exchangers in the Process Industries

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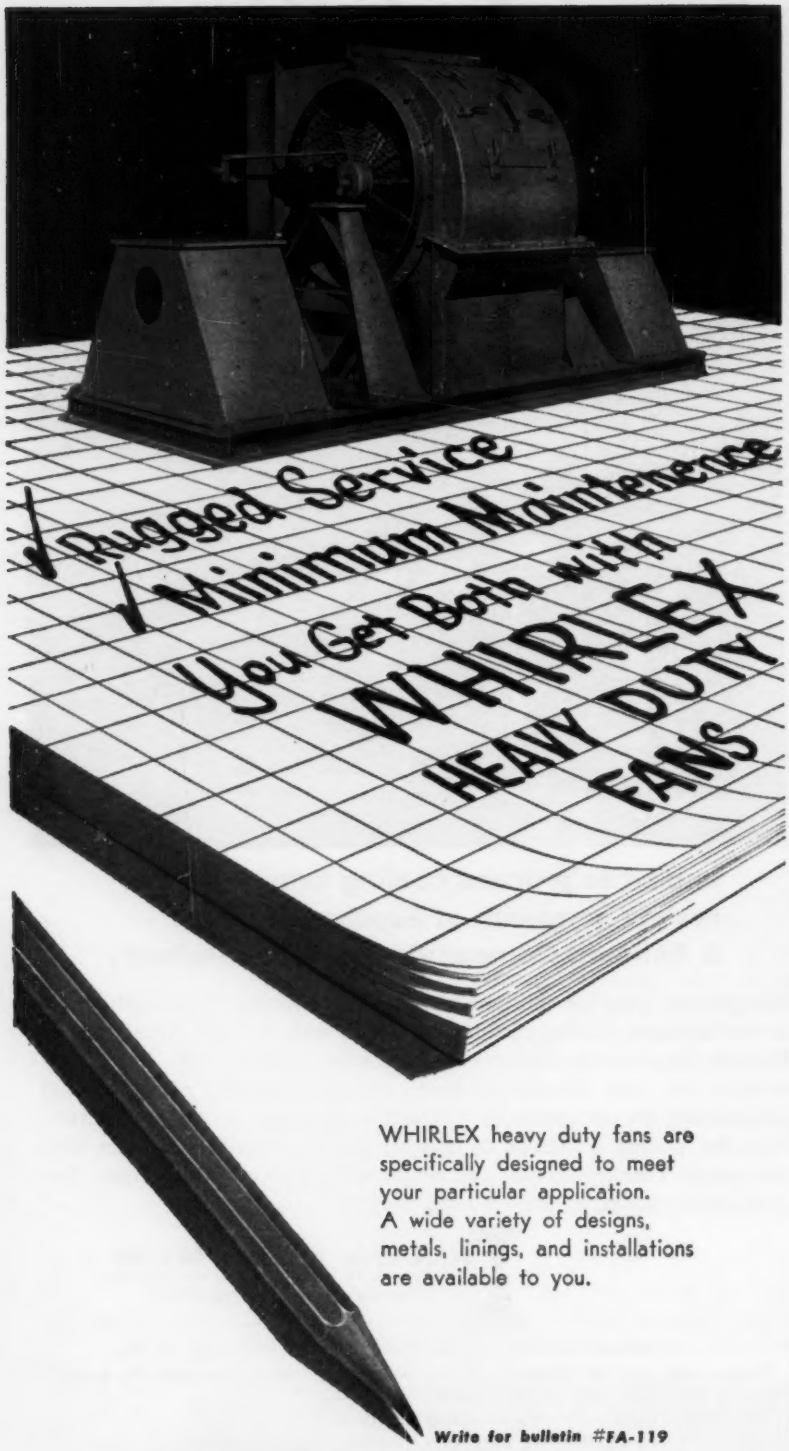

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Building . . .

ery and industrial complex, with construction to begin next spring.

- At Nagoya—two refining units with 30,000-bpd capacity each.
- At Osaka—100,000-bpd refinery as part of a petrochemical center.

Mo och Domsjo Aktiebolag will build Sweden's first direct air oxidation ethylene oxide plant at Stenungsund. The 33-million-pound-per-year installation will be designed and engineered by Scientific Design Co., Inc. Mo och Domsjo will also erect an ethylene glycol plant designed by SD.

E. I. du Pont de Nemours & Co., Inc., will build an isocyanates plant at Maydown, near Londonderry, Northern Ireland. Construction will begin later this year on the plant, which will be adjacent to Du Pont's neoprene synthetic rubber facility. On stream date should be late in 1963.

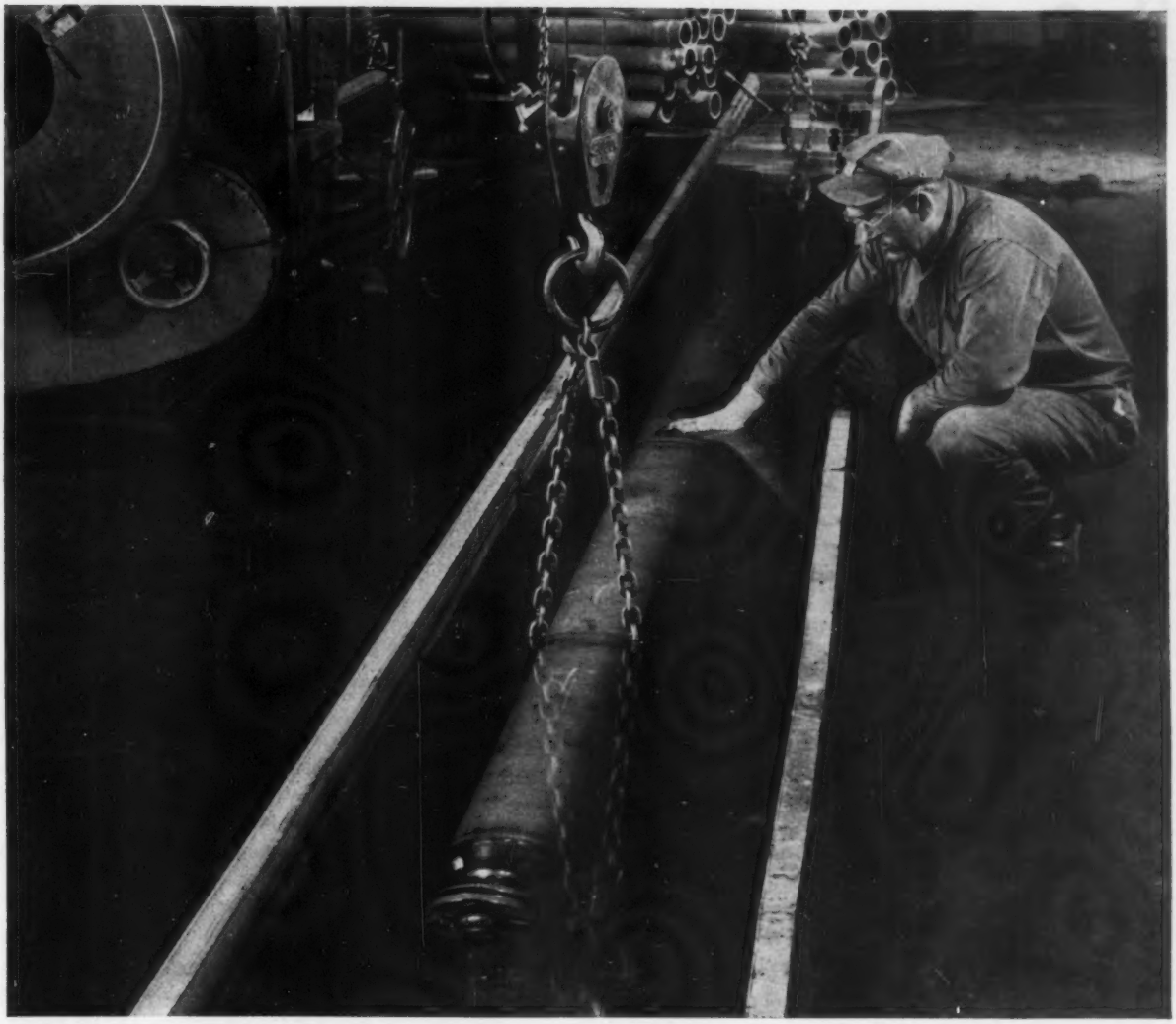
Gulf Oil Corp. and Societa Italiana Resina have established a firm to build a phenol-acetone plant on the island of Sardinia. The new company, Societa Italiana Resina Gulf, will operate the plant at Porto Torres, making 70,000 tons per year of phenol-acetone by 1962.

Mobil Oil Co. reports that construction on its Mersin, Turkey, refinery are proceeding on schedule. The plant is expected to be on stream by the end of the year. Mobil owns a 56-percent interest in the 65,000-bpd refinery.

American Independent Oil Co. will build a refinery in Southern Rhodesia between Salisbury and Umtali at a cost of $36.4 million. Other plans for the area include a nitrogenous fertilizer plant and petrochemical facilities.

Hudson's Bay Oil & Gas Co., Ltd., is expected to finish construction on a 160-MMcfd gas dehydration plant in December 1961 at Pine Creek field, Alta.

Petrobras has given Hudson Engineering Corp., Houston, a contract to design and construct a natural gas processing plant at Catu, Bahia, Brazil, to cost approximately $5.5 million.



Air Pressure—Just one of seven tests on Reformer Tubes before they leave Electro-Alloys

It takes seven thorough inspections to assure you leakproof service . . . and each of our tube assemblies goes through them all. The air inspection shown above tested these tubes underwater at 100 psi.

At the beginning of the test series, each tube section receives an *air test* and a *hydrostatic test*. Then the tubes are assembled by welding and each weld checked three ways—*Borescope*, *Dyckek* and *X-ray*. We repeat the *air* test and the *hydrostatic* test with the complete assemblies. During the test series and at the end of it, there is careful visual inspection by experienced personnel.

A *chemical analysis* assures composition control when the tubes are cast. All this adds up to positive protection against costly leaks.

For reformer tubes that provide leakproof service, specify Electro-Alloys centrifugally cast tubes . . . backed by years of casting experience.

Call your nearest representative or write: Electro-Alloys Division, American Brake Shoe Company, 3030 Taylor St., Elyria, Ohio.

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INHIBIT HYDRATE FORMATION BY GLYCOL INJECTION

Gas hydrates are crystalline compounds formed by the chemical combination of natural gas and water. These hydrates form under pressure at temperatures considerably above the freezing point of water.

Problems associated with the freezing of free water and/or hydrate formation are often encountered in low temperature processing of natural gas for the recovery of light hydrocarbons. In processing of gases below their water-vapor dew points, hydrate formation can be prevented by the injection of a freezing point depressant.

CHOICE OF HYDRATE INHIBITOR

The inhibitors which have been most widely used are ethylene glycol, diethylene glycol and methanol. The glycols are preferred in most cases since they can be recovered and reused. The glycols are normally injected as an 80 to 85 wt.% aqueous solution. Injection rates are set on the basis of the water content of the gas so that a maximum 10 to 15 wt.% further water dilution of the glycol occurs.

Proper choice of the glycol to be used is dependent primarily on the temperatures involved during the injection and recovery of the glycol solution. Roughly speaking, ethylene glycol should be considered for temperatures below 0 to − 20°F. and diethylene glycol above this temperature range. Ethylene glycol has the advantage over diethylene glycol of being less viscous at low temperatures, less soluble in the hydrocarbon condensate and cheaper. At higher temperatures diethylene glycol may be preferred due to lower glycol vaporization losses.

DESIGN CONSIDERATION AND OPERATING PROBLEMS

One of the more common problems encountered in glycol injection systems is loss of glycol to the hydrocarbon phase due to insufficient residence time in the glycol-hydrocarbon condensate separator.

Although the solubility of glycol in hydrocarbon is decreased by lowering the separator temperature, this effect is lost if the settling time in the separator is too short to allow for complete breakdown of the hydrocarbon-glycol emulsion normally formed. Settling or residence time in the separator will vary from 4 to 60 minutes depending on process conditions.

Removal of entrained heavy hydrocarbons from the gas prior to low temperature processing and glycol injection is necessary to prevent a build-up of tar-like materials in the system that cause filter and injection nozzle fouling as well as erratic pump operations.

The formation of emulsions of the glycol solution and hydrocarbon condensate can often occur as a result of contamination of the glycol solution by oil field treating chemicals, compressor lubricating oils and valve lubricants. Where this problem occurs, the best approach is to eliminate the source of contamination. If the source of contamination cannot be located or eliminated, the use of demulsifiers or emulsion-breakers will often control emulsion formation.

Proper dispersion of the glycol solution into the gas stream prior to chilling or expansion is a must. Spray nozzles are the most commonly used means of dispersing the glycol in the gas streams and are usually located a short distance upstream of the chiller or choke. Manufacturers of the various type spray or fogging nozzles should be consulted to assure the proper choice of nozzle for any given set of conditions. It is important that glycol be dispersed sufficiently in the gas stream so that all chiller tubes are protected against hydrate formation. Formation of hydrates in any of the chiller tubes causes an increase in velocity and pressure drop through the remainder of the tubes which increases the possibility of their freezing. Excessive velocity of the gas through the tubes is also conducive to foaming and formation of emulsions.

For complete information on Jefferson glycols, ethanolamines, and helpful technical services . . . contact Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

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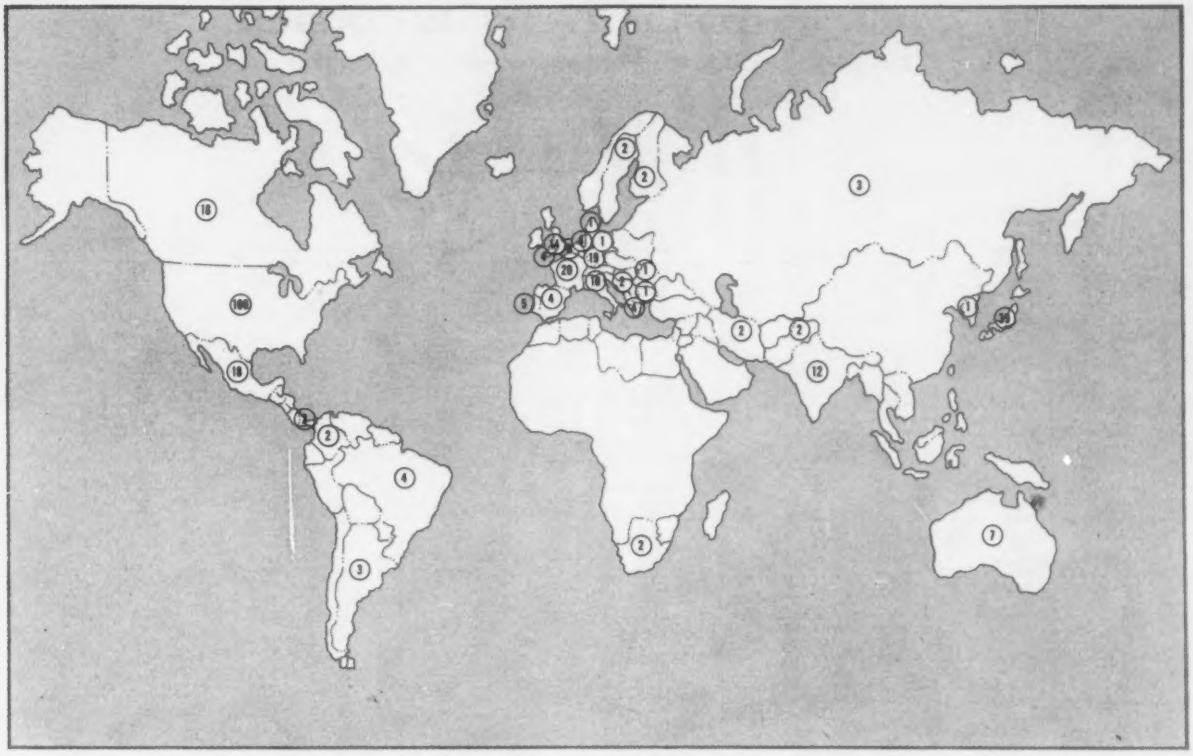


Petrochemicals projects presently being built or engineered throughout the world.

Petrochemicals Climbing HPI Ladder

Gordon M. Fales,
Departments Editor

A survey of two HPI Construction Boxscores, October 1960 and October 1961, reveals a big increase in petrochemicals construction and planning on a worldwide basis. This article highlights construction and planned projects showing their increase over last year's figures. An accompanying table compares the world total to the U.S. share.

Petrochemicals, fast becoming number one in HPI's big three (refining, petrochemicals and gas processing), had 110 more under construction and engineering entries in this month's HPI Construction Boxscore than in October 1960. The tabulation carried 205 listings last year for under construction and engineering, whereas this October's Boxscore shows 315.

Overall construction and engineering in Boxscore totals about 600 entries. This means that petrochemicals, with its 315, dominates a little more than half of the tabulation.

Planned projects number 76 for petrochemicals in this report, while last year there were 54. Planning in the United States was listed 14 times in October 1960. This year 22 petrochemical projects are planned.

U.S. Construction

For all categories in the United States, petrochemical construction and engineering came to 91 entries in 1960. This year's count numbers 100 projects. The greatest amount of petrochemical construction activity for the U.S. for both this year and last appears in the East and Southwest sections.

Cost Range

Millions of dollars are being spent in the U.S. and abroad for petrochemical construction. For example, Oxo Chemical Co. is building a $100-million oxo alcohol facility at Portsmouth, Ohio. On the foreign scene, Montecatini is constructing a petrochemical complex at Brindisi, Italy, at a cost of $95 million.

Three petrochemicals which number high in the Boxscore are ethylene and ammonia, the strongest, and polyolefins running a close third.

HPI Construction Boxscore appears quarterly in HYDROCARBON PROCESSING & PETROLEUM REFINER, this being its fourteenth year.

	WORLD		U.S. PORTION	
	1960	1961	1960	1961
Under Construction & Engineering	205	315	91	100
Planning	54	76	14	22

HPI Construction Boxscore

Hydrocarbon Processing Plants

East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Air Products	Iselin, N.J.	Liquid Helium	.....	.....	Under Constr	.....	.....	.....	.....
Allied Chemical	Moundsville, W. Va.	Exp. Chlorinated Methane	.....	.....	Under Constr	.....	.....	.....	.....
		Isocyanate	.....	.....	Under Constr	Early 1962	.....	.....	.....
American Rubber & Chemical	Louisville, Ky.	Polybutadiene, Polyisoprene	30,000 tons/yr	.....	Under Constr	1961	Phillips	Staff	Braun
		Synthetic Rubber	.....	.....	Under Constr	1961	Phillips	Braun	Braun
Armour Agricultural Chemical	Cherokee, Ala.	Urea	50 tons	.....	Under Constr	1962	.....	Kellogg	Kellogg
		Ammonia	360 tons	.....	Under Constr	1962	.....	Kellogg	Kellogg
Ashland O & R	Ashland, Ky.	Toluene	10,000,000 gals/yr	.....	Complete	.....	UOP	Procon	Procon
		Xylene	10,000,000 gals/yr	.....	Under Constr	1961	UOP	Procon	Procon
Atlantic Refining	Philadelphia, Pa.	Exp. Alkylation	7,500 bbls	.....	Under Constr	Late 1961	.....	Kellogg	Staff
Avi Sun	New Castle, Del.	Polypropylene Resin	75,000,000 lbs/yr	$30,000,000	Under Constr	1961	Staff	Bechtel	Bechtel
California Oil	Perth Amboy, N.J.	*Phthalic Anhydride	30,000,000 lbs/yr	$5,000,000	Engineering	Late 1962	Cal Research	Badger Mfg	Badger Mfg
Cary Chemical	Burlington N.J.	*Polyvinyl Chloride	.....	.....	Under Constr	June 1962	.....	Blaw-Knox	Blaw-Knox
Collier Carbon & Chemical, Tidewater Oil	Delaware City, Del.	Naphthalene	100,000,000 lbs/yr	.....	Under Constr	1961	Union Oil-Cal	Catalytic	Catalytic
Du Pont	Belle, W. Va.	Methyl Methacrylate	.....	.....	Planning	1961	.....	.....	.....
	Memphis	Acrylonitrile	.....	.....	Under Constr	1961	.....	.....	.....
Escambia Chemical	Pensacola, Fla.	*Urea	50 tons	.....	Engineering	Late 1961	Chemico	Chemico	.....
Florida Southern Oil	Jacksonville, Fla.	Refinery	15,000 bbls	.....	Planning	.....	.....	.....	.....
Foster Grant	Leominster, Mass.	Plastic Polymers, Copolymers, Styrene Monomer, Molded Plastics	.....	$4,000,000	Planning	.....	.....	.....	.....
Goodrich-Gulf Chemicals	Institute, W. Va.	cis-Polybutadiene	20,000,000 lbs/yr	.....	Engineering	March 1962	Staff	Blaw-Knox	Blaw-Knox
Gulf Oil	Philadelphia, Pa.	*Bensene-Cumene	.....	.....	Engineering	Mid 1962	.....	.....	.....
Hatco Chemical	Fords, N.J.	Phthalic Anhydride	22,000,000 lbs/yr	$2,500,000	Complete	.....	Sherwin-Williams	Badger Mfg	Badger Mfg
Hess Trading & Transport	Sewaren, N. J.	Exp. Refinery	35,000 bbls	.....	Planning	.....	.....	.....	.....
		Udex	.....	.....	Planning	.....	.....	.....	.....
		Catalytic Cracking	.....	.....	Planning	.....	.....	.....	.....
Heyden Newport Chemical	Fords, N.J.	Maleic Anhydride	24,000,000 lbs/yr	.....	Under Constr	1961	.....	S D	S D
		Fumaric Acid	.....	.....	Complete	.....	S D	.....	.....
Hooker Chemical	South Shore, Ky.	Phenol	.....	.....	Under Constr	Mid 1962	Staff	Blaw-Knox	Blaw-Knox
Monsanto Chemical	Logan Township, N.J.	Phthalic Anhydride	.....	.....	Under Constr	1961	Sherwin-Williams	Badger Mfg	Badger Mfg
		*Plasticizer	.....	.....	Under Constr	1961	.....	Catalytic	Catalytic
Novamont	Neal, W. Va.	Isotactic Polypropylene, Other Petrochemicals	30,000,000 lbs/yr	.....	Under Constr	1961	Montecatini	Staff	Staff
Olin Mathieson	Saltville, Va.	Hydrazine	.....	$14,000,000	Complete	.....	.....	McKee	McKee
Pittsburgh Chemical	Neville Island, Pa.	Exp. Vinyl Plasticizers	.....	.....	Under Constr	Jan 1962	.....	Staff	Staff
Quaker State Oil Ref.	St. Marys, Va.	Propane Deresining	700 bbls	.....	Engineering	.....	.....	Foster Wheeler	Foster Wheeler
Reichhold Chemicals	Tuscaloosa, Ala.	Formaldehyde	35,000,000 lbs/yr	.....	Planning	.....	Staff	Staff	Staff
		Phenol	.....	$2,500,000	Under Constr	Late 1961	Staff	Staff	Staff
Shell Chemical	Woodbury, N.J.	Polypropylene	.....	.....	Under Constr	1962	Shell	Braun	Braun
Standard-Kentucky/ Standard-California	Pascagoula, Miss.	*Refinery	100,000 bbls	.....	Engineering	.....	.....	.....	.....
Sun Oil	Marcus Hook, Pa.	Automatic Tank Gauging	.....	$428,000	Under Constr	1961	.....	Staff	Staff
		Crude Blending	.....	$230,000	Under Constr	1961	.....	Staff	Staff
		*Fluid Cat Cracking	84,000 bbls	$14,000,000	Engineering	Oct 1962	UOP	Staff/UOP	.....
		*Gas Recovery	.....	$9,300,000	Under Constr	Nov 1961	Staff	Staff	Catalytic
Sun Olin Chemical	Claymont, Del.	Ethylene	685,000 lbs	$17,000,000	Under Constr	Jan 1962	.....	Lummus	Lummus
		Ethylene Oxide	164,000 lbs	$3,000,000	Under Constr	Jan 1962	Shell	Lummus	Lummus
		Carbon Monoxide	1,000,000 scf	$2,500,000	Under Constr	Jan 1962	.....	Air Products/ Kellogg	Air Products/ Kellogg
		Hydrogen	12,000,000 scf						
Tennessee Corp.	East Tamps, Fla.	Ammonia	100,000 tons/yr	$13,000,000	Planning	Early 1962	.....	.....	.....
Tidewater Oil, Air Products	Delaware City, Del.	Oxo Alcohols	90,000 lbs	.....	Planning	1962	.....	.....	.....
Union Carbide	Institute, W. Va.	Phthalic Anhydride	50,000,000 lbs/yr	.....	Engineering	1962	Sherwin-Williams	Badger	.....
U.S. Steel	Clairton, Pa.	Tar Distillation	.....	.....	Complete	.....	.....	McKee	McKee
U.S. Phosphoric Products	East Tampa, Fla.	Ammonia	300 tons	.....	Engineering	Late 1961	Chemico	Chemico	Chemico
Witco Chemical	Perth Amboy, N.J	Phthalic Anhydride	30,000,000 lbs/yr	.....	Under Constr	.....	S D	S D	S D

Mid-Continent

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	South Point, Ohio	Exp. Methanol	50%	.....	Complete	.....	.....	.....	.....
		Exp. Formaldehyde	35%	.....	Complete	.....	.....	.....	.....
American Oil	Mandan, N.D.	Naphtha Desulfurizer	.....	.....	Under Constr	1961	.....	Staff	Parsons
	Wood River, Ill.	LPG Treating	.....	.....	Under Constr	1961	.....	Staff	Staff
	Sugar Creek, Mo.	Crude Distillation	70,000 bbls	.....	Engineering	Summer 1962	.....	Parsons	Parsons
Amoco Chemicals	Joliet, Ill.	Exp. Esters	.....	.....	Engineering	1961	Staff	Tears	Staff
		Trimellitic Anhydride	.....	.....	Under Constr	1961	.....	S D	S D
Apco Oil	Arkansas City, Kan.	*Lomax	2,950 bbls	.....	Planning	.....	UOP	Procon	Procon
Borden Chemical	Illiopolis, Ill.	Polyvinyl Chloride	40,001,000 lbs/yr	$4,000,000	Planning	.....	.....	.....	.....
California Chemical	Ft. Madison, Iowa	Ammonia	300 tons	.....	Under Constr	Late 1961	.....	Staff/Bechtel/ C & I	Bechtel/C & I
		Nitric Acid	250 tons						
		Ammonium Nitrate	150 tons						
		Complex Fertilizer	600 tons						
Champlin Oil & Refining	Enid, Okla.	Delayed Coker	4,000 bbls	$1,500,000	Under Constr	Oct 1961	.....	Staff/Fluor	Staff/Fluor
Cities Service	Ulysses, Kan.	*Helium Extraction	2 MMcf	.....	Engineering	Early 1963	.....	.....	.....

*First appearance in tabulation.

Please don't feed the "TUBE EATERS"

Don't let unnecessary pitting, cracking or erosion chew up tubes before their time. Don't let *any* type of corrosion, scale or biofouling hamper your heat exchange efficiency without checking these four factors:

• Is the tube alloy *right?* Will a vital difference in corrosion resistance result from a minor alloy change—or is an entirely different alloy called for? • How much will performance be improved by Duplex bi-metallic tubes which provide the best metal or alloy for *each* heat transfer medium. • Will a change to thickened-end or thickened-center tubes give needed extra resistance where attack is most severe? • What actual data on similar exchanger operations are available?

We at Bridgeport can help you. Our condenser tube experience dates back to 1900 but our files are completely up-to-date on tube problems reflecting the high pressures, temperatures and velocities of modern operations. Write Bridgeport Brass Company, Bridgeport 2, Connecticut.

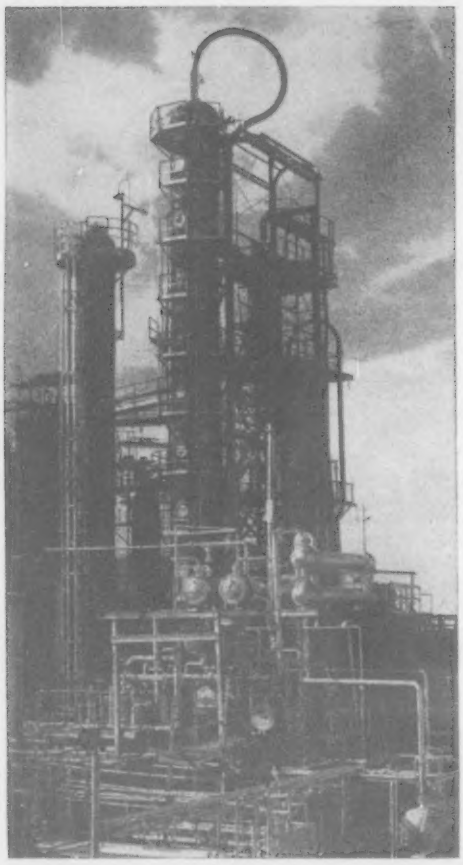
Bridgeport condenser and heat exchanger tubes in over 50 metals and alloys:

INHIBITED ADMIRALTY
INHIBITED ALUMINUM BRASS
INHIBITED MUNTZ METAL
70-30 CUPRO NICKEL
90-10 CUPRO NICKEL
DEOXIDIZED ARSENICAL COPPER
INHIBITED ALUMINUM BRONZE
RED BRASS
ALLOY 77 MERCURY BRASS

...plus **DUPLEX TUBES**...in combinations of the above alloys, with carbon or stainless steel, aluminum, Monel,® nickel...or other metals.

BRIDGEPORT BRASS COMPANY

Bridgeport



Specify Wilson-Snyder

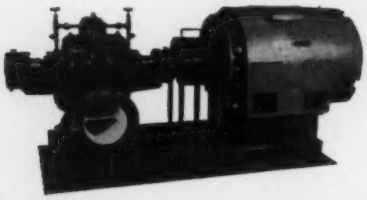
. . . and KNOW you are getting the type of pump that is BEST for your refinery applications

Since 1878, the Wilson-Snyder trade name has been synonymous with the highest quality in heavy-duty pumps. Their performance records in thousands of refinery installations throughout the United States and in foreign countries have established them as the industry's finest pumps.

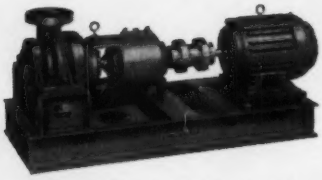
While centrifugal pumps are widely used for process work, there are specific applications for which reciprocating pumps offer definite advantages from the standpoint of both performance and economy.

As a manufacturer of both centrifugal and reciprocating types (including both power-driven and direct-acting steam-driven), you can be sure our unbiased recommendation will be the type best suited for your specific applications.

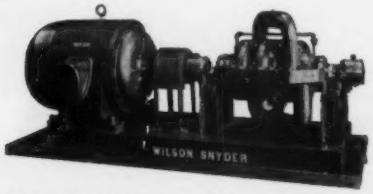
Here are Four Popular Types



SINGLE-STAGE DOUBLE-SUCTION CENTRIFUGAL PUMPS . . . These pumps are heavy-duty double volute construction and include all important features of hydraulic design for highest efficiency over a broad range of operation. Available in sizes up to 30 inch for capacities to 33,000 GPM with up to 300 ft. head and up to 1,500 input hp. All parts subject to fluid contact can be furnished in materials best suited to the conditions of service.

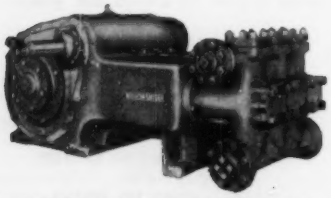


ESN CENTRIFUGAL PROCESS PUMPS . . . These all-new single or 2-stage heavy-duty pumps offer double-volute case design for maximum radial balance at all conditions in all sizes—from 3" discharge and larger. Designed for temperatures to 900° F. in a choice of end or top suction construction. Only five bearing bracket assemblies cover the complete line. Twenty-one sizes ranging up to 350 hp input provide capacities to 2,000 GPM and heads to 1,300 ft. ESN pumps can be furnished in a wide range of metallurgy, including alloys suitable for highly corrosive and abrasive liquids.



MULTI-STAGE CENTRIFUGAL PUMPS . . . Opposed impeller type—built for high efficiency and long service life. The opposed impellers and staggered volutes provide inherent hydraulic and radial balance. Passages of correct hydraulic design produce a smooth flow of liquid at correct velocity for maximum pump efficiency. Available in a variety of materials best suited for conditions of service.

These pumps available for capacities to 3,500 GPM and pressures to 1,600 psig for up to 2,000 input hp.



TRIPLEX PLUNGER-TYPE POWER PUMPS . . . Designed for handling a wide range of products, including highly volatile liquids over a wide temperature range, and time-proven in high-pressure charge pump service. Available in 3", 4", 6" and 8" stroke sizes for capacity requirements to 700 GPM and pressures to 5,650 psi.

Convenient Application Service

. . . on Wilson-Snyder Process Pumps can be secured through your nearest "Oilwell" Branch . . . or direct from WILSON-SNYDER SALES ENGINEERS at . . . Chicago, Illinois . . . Dallas, Texas . . . Houston, Texas . . . Los Angeles, California . . . New York, N. Y. . . . Tulsa, Oklahoma . . . Pittsburgh, Pa.

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Wilson-Snyder Works
Oil Well Supply Division USS **United States Steel**

Executive and Export Offices—Dallas, Texas

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Cooperative Farm Chemicals	Lawrence, Kan.	Ammonia	100 tons	$5,400,000	Complete	.....	.....	Chemico	Chemico
		Urea	30 tons						
		*Nitric Acid	120 tons	$1,200,000	Under Constr	Nov 1961	Chemico	Chemico	Chemico
		*Ammonium Nitrate Prilling	600 tons	$500,000	Under Constr	Dec 1961	Chemico/Staff	Chemico/Staff	Chemico/Staff
	Hastings, Neb.	*Ammonia	200 tons	.....	Under Constr	Dec 1961	.....	.....	.....
Dow Chemical	Midland, Mich.	Exp. Styrene Monomer	.....	.....	Under Constr	.....	.....	.....	.....
	Bay City, Mich.	Polypropylene	.....	.....	Under Constr	.....	.....	.....	.....
DX Sunray	Tulsa, Okla.	Crude Distillation	85,000 bbls	$6,500,000	Under Constr	1961	.....	Foster Wheeler	Foster Wheeler
		Hydeal	1,000 bbls	$1,100,000	Complete	.....	UOP	UOP	Foster Wheeler
El Paso Natural Gas	Beaver, Okla.	*Gasoline	40 MMcf	.....	Under Constr	1961	.....	Dresser	Dresser
Ben Franklin Refining	Ardmore, Okla.	Crude	25,000 bbls	.....	Under Constr	1961	.....	Tears	Tears
Goodyear Tire & Rubber	Akron, Ohio	Exp. Nitrile & Latex	.....	.....	Complete	.....	.....	.....	.....
Gulf Oil	Cincinnati, Ohio	*Refinery Modernization	.....	.....	Engineering	Fall 1962	.....	Bechtel	Bechtel
Helex	Bushton, Kan.	*Helium Recovery	2 MMcf	.....	Engineering	June 1962	.....	Fluor	Fluor
Horse Shoe Gallup Gasoline	Farmington, N.M.	*Exp. Propane Recovery	to 3.5 MMcf	.....	Under Constr	1961	.....	Portable Gasoline Plants	Portable Gasoline Plants
Humble Oil & Refining	Hennessey, Okla.	*Gas Products	77 MMcf	$7,500,000	Under Constr	1962	.....	Dresser	Dresser
Hunt Oil	Tioga, N.D.	Gasoline	9 MMcf	.....	Planning	Nov 1961	.....	.....	.....
Lyda Hunt-Herbert Trusts	McGregor, N.D.	*Gasoline	12 MMcf	$2,000,000	Under Constr	Dec 1961	.....	Olsen	Olsen
Mack Oil	Healdton, Okla.	Gasoline	6 MMcf	.....	Engineering	1961	.....	Dresser	Dresser
Monsanto Chemical	Monsanto, Ill.	Exp. Phenol	.....	.....	Under Constr	1961	.....	.....	.....
	El Dorado, Ark.	Urea Distillation	.....	.....	Under Constr	.....	.....	Chemico	Chemico
	St Louis	Exp. Maleic Anhydride	20,000,000 lbs/yr	.....	Under Constr	.....	.....	S D	S D
Murphy	Superior, Wis.	Fluid Cat Cracking	5,000 bbls	.....	Engineering	Early 1962	UOP	Sweco	Sweco
		Alkylation	1,000 bbls	.....	Engineering	Dec 1961	UOP	Sweco	Sweco
National Cooperative Refinery	McPherson, Kan.	Delayed Coker Revamp	.....	$1,200,000	Under Constr	Oct 1961	.....	Staff/UOP	Procon
Northern Gas Prod.	Bushton, Kan.	Hydrocarbons Recovery	896 MMcf	$10,000,000	Under Constr	1961	.....	Fluor	Fluor
Ohio Oil	Robinson, Ill.	Fluid Cat Cracking Revamp	12,000-18,000 bbls	$1,250,000	Complete	.....	UOP	UOP	Staff
Oxo Chemicals	Portsmouth, Ohio	Oxo Alcohol	.....	$100,000,000	Engineering	1962	.....	Fluor	Fluor
Panhandle Eastern Pipe Line	New Baltimore, Mich.	*Hydrocarbons Recovery	25 MMcf	.....	Under Constr	Nov 1961	.....	Chem-Gas	Litwin
Pennsalt Chemical	Wyandotte, Mich.	Alkylalkanolamines	7.5 MM lbs/yr	$2,000,000	Under Constr	Early 1962	Staff	Catalytic	Catalytic
		Exp. Alkylamines	.....	.....	Under Constr	Feb 1962	.....	Blaw-Knox	Blaw-Knox
Phillips Chemical	E. St. Louis, Ill.	Ammonia Storage	15,000 tons	.....	Complete	.....	.....	Girdler	Girdler
Pure Oil	Lemont, Ill.	BTX	70,000 gals	.....	Under Constr	Late 1961	UOP	UOP/Procon/Staff	Procon
		*Heptane, Hexane	.....	.....	Under Constr	Early 1962	.....	Procon/Staff	Procon
	Newark, Ohio	*HF Alkylation	1 425 bbls	.....	Engineering	Early 1962	.....	.....	Kaighin-Hughes-Litwin
RJ Oil & Refining	Princeton, Ind.	Unifiner	1,800 bbls	.....	Under Constr	Late 1961	.....	UOP	Staff
		Crude Distillation	6,000 bbls	.....	Under Constr	Late 1961	.....	UOP	Staff
		Platformer	1,800 bbls	.....	Under Constr	Late 1961	.....	UOP	Staff
		Thermal Cracking	2 200 bbls	.....	Under Constr	Late 1961	.....	UOP	Staff
Shell Chemical	Marietta, Ohio	Synthetic Rubber	.....	.....	Under Constr	1961	Shell	Braun	Braun
Shell Oil	Wilson, Okla.	*Gasoline Revamp	7 MMcf	.....	Engineering	Late 1961	.....	Dresser	Dresser
Signal Oil & Gas	Tioga, N.D.	Exp. Amine, Natural Gas Liquids	80 MMcf	$1,500,000	Engineering	1961	.....	.....	.....
Sinclair Refining	Wood River, Ill.	Heptene	265 bbls	.....	Complete	.....	.....	Procon	Procon
Skelly Oil	El Dorado, Kan.	*Exp. Cat Cracking	to 20,500 bbls	.....	Engineering	April 1962	Kellogg	Kellogg	Staff
		*Vapor Recovery	.....	.....	Engineering	April 1962	.....	Kellogg	Staff
		*Exp. Alkylation	6,600 bbls	.....	Engineering	April 1962	Phillips	Staff/Phillips	Staff
Solar Nitrogen	Joplin, Mo.	Urea	150 tons	$15,000,000	Under Constr	Oct 1961	Stamicarbon	McKee/Stamicarbon	McKee
		Solutions Blending	25,000 tons/yr	.....	Engineering	Nov 1961	.....	Stand-Ohio	Nofsinger
Standard-Ohio	Toledo, Ohio	Isocracker	7,500 bbls	$4,000,000	Under Constr	Late 1961	Cal Research	Parsons/Cal Research	Parsons
	Cleveland, Ohio	LPG Storage	.....	$560,000	Under Constr	Spring 1962	.....	Staff	Staff
		Gasoline Blending	.....	$692,000	Engineering	Spring 1962	.....	Staff	.....
Sun Oil	Toledo	Naphthalene	100,000,000 lbs/yr	$8,000,000	Under Constr	Late 1961	.....	Staff	Kellogg
		Automatic Tank Gauging	.....	$200,000	Under Constr	1961	.....	Staff	Staff
Texaco	Beaver County, Okla.	Exp. Gasoline	to 70 MMcf	.....	Under Constr	Dec 1961	.....	Olsen	Olsen
	Lockport, Ill.	*Delayed Coking	28,000 bbls	.....	Under Constr	Mid 1962	.....	Foster Wheeler	Foster Wheeler
TXL Oil	Lignite, N.D.	*Gasoline	20 MMcf	$1,750,000	Engineering	1961	.....	Pona	.....
		*Sulfur	20 tons	$150,000	Under Constr	Late 1961	Pan American	Pona	Staff
Union Carbide	Marietta, Ohio	Bisphenol-A	25,000,000 lbs/yr	.....	Under Constr	1961	.....	.....	.....

Southwest

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	Orange, Texas	Polyethylene Glycol	.....	.....	Complete	.....	.....	.....	.....
	Baton Rouge, La.	Polyethers	20,000,000 lbs/yr	.....	Complete	.....	.....	.....	.....
Aluminum Co. of America	Point Comfort, Texas	Exp. Natural Gasoline	150 MMcf	.....	Under Constr	1961	.....	Olsen	Olsen
Amarillo Oil	Fritch, Texas	*Exp. Gasoline	to 60 MMcf	.....	Engineering	1962	.....	Dresser	Dresser
American Oil	Texas City	Crude Distillation	150,000 bbls	.....	Under Constr	1961	.....	Kellogg	Kellogg
		Cat Cracker	47,600 bbls	.....	Under Constr	1961	.....	Kellogg	Kellogg
		Cooling Water	.....	.....	Under Constr	1961	.....	Tears	Tears
		Alkylation	14,600 bbls	$7,000,000	Under Constr	1961	.....	Fluor	Fluor
		Isomerization	12,600 bbls						
		Butane Splitting							
		Delayed Coking Revamp	.....	.....	Engineering	Nov 1961	.....	Tellepsen	Tellepsen
		Cat Cracker Revamp							
		Crude Charge	.....	.....	Under Constr	1961	.....	Tears	Tears
Amoco Chemicals	Texas City	Petroleum Resins	.....	.....	Under Constr	1961	.....	Bechtel	Bechtel
Atlantic Refining	Port Arthur, Texas	Sulfur	35 tons	$250,000	Complete	.....	Pan American	Pona	Pona
		Aromatics Prefractionation	5,500 bbls	.....	Under Constr	Late 1961	.....	Parsons	Parsons
		*Deisobutanizer	5,500 bbls	.....	Under Constr	Jan 1962	.....	Staff	.....
	George West, Texas	Gasoline	90 MMcf	.....	Under Constr	Oct 1961	.....	Olsen	Olsen
California Chemical	Oak Point, La.	Exp. Lube Oil Additives	2,400,000 gals/yr	$1,000,000	Complete	.....	.....	Staff	.....
Carbide & Carbon	Seadrift, Texas	Exp. Polyethylene	.....	.....	Engineering	.....	.....	B & R	.....
	Texas City	Exp. Ethylene Glycol	65 MMcf		Planning	.....	.....	.....	.....
Carwin	Houston	Special Isocyanates	1,500,000 lbs/yr	$1,000,000	Under Constr	1961	.....	Pona	Mundy Constr

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Celanese	Bay City, Texas	Petrochemicals	.....	.....	Under Constr	Early 1962	Aldehyd	B & R	B & R
	Bishop, Texas	Acetal Copolymer	.....	.....	Under Constr	Early 1962	.....	B & R	B & R
		Exp. Butanol	.....	.....	Complete	.....	.....	Staff	.....
Cities Service	Lake Charles, La.	*H-Oil	2,500 bbls	.....	Engineering	Fall 1962	Hydrocarbon/Staff	Hydrocarbon	Hydrocarbon
	Calhoun County, Texas	*Natural Gasoline	10 MMcf	.....	Under Constr	Dec 1961	.....	.....	Austin Rankin
Coastal Products	Corpus Christi, Texas	Delayed Coking	7,000 bbls	$3,000,000	Complete	.....	.....	Treco	Treco
		*Alkar-Styrene	60,000,000 lbs/yr	.....	Under Constr	Early 1962	UOP	UOP	Parsons
Columbian Carbon	North Bend, La.	Exp. Carbon Black	.....	.....	Under Constr	1961	Staff	Ford, Bacon & Davis	Ford, Bacon & Davis
Continental Oil	Lake Charles, La.	Straight-Chain Primary Alcohols	50,000,000 lbs/yr	.....	Under Constr	1961	.....	Lummus	Lummus
		Exp. Natural Gasoline	to 150 MMcf	.....	Under Constr	1961	.....	Hudson	Hudson
	Westlake, La.	*Methyl Chloride	.....	.....	Under Constr	Feb 1962	Ansul Chem	Blaw-Knox	Blaw-Knox
Copolymer Rubber & Chemical	Baton Rouge, La.	Exp. Butadiene	to 55,000 tons/yr	$5,000,000	Complete	.....	Dow	Foster Wheeler	Foster Wheeler
Cosden Petroleum	Big Spring, Texas	Exp. Polystyrene	to 40,000,000 lbs/yr	.....	Complete	.....	Staff	Staff	Staff
		Chemical Polymers	2,500,000 gal/yr	$500,000	Complete	.....	.....	Staff	Staff
		Ortho-Xylene	70,000,000 lbs/yr	.....	Complete	.....	.....	.....	.....
Crown Central Pet.	Pasadena, Texas	Udex, Reformer Revamp	.....	$3,750,000	Under Constr	Late 1961	UOP	Tellepsen	Tellepsen
		Orthoxylene	.....	.....	Under Constr	1961	UOP	Tellepsen	Tellepsen
		Detol	17,000,000 gal/yr	.....	Complete	.....	Houdry	Catalytic	Catalytic
Diamond Alkali	Deer Park, Texas	Acetylene	.....	.....	Under Constr	Early 1962	Montecatini	Braun	Braun
		Ammonia	.....	.....	Engineering	Early 1962	.....	.....	.....
Dow Chemical	Freeport, Texas	Acrylonitrile	.....	.....	Under Constr	1961	.....	Staff	.....
		Exp. Ethylene	67%	.....	Under Constr	1961	.....	Staff	.....
	Plaquemine, La.	Polyethylene B	.....	$6,000,000	Under Constr	Mid 1962	.....	Staff	.....
Du Pont	Orange, Texas	Polyethylene	.....	.....	Under Constr	.....	.....	.....	.....
	Beaumont, Tex.	Caprolactum	50,000,000 lbs/yr	.....	Under Constr	.....	.....	Staff	Staff
		Acrylonitrile	.....	.....	Under Constr	Spring 1962	Staff	Staff	Staff
El Paso Natural Gas	Midkiff, Texas	*Ethane Recovery	1,750 bbls	$273,000	Under Constr	Oct 1961	.....	Stearns-Roger	Stearns-Roger
El Paso Natural Gas Products	Odessa, Texas	Ethylene	150,000,000 lbs/yr	.....	Engineering	Late 1961	.....	UOP/Fish	Fish
		Benzene	15,000,000 gals/yr	.....	.....	1961	UOP	UOP/Nofsinger	Ref-Chem
Esso Standard	Baton Rouge, La.	Exp. Butyl Rubber, Stage II	18,000 tons/yr	$8,000,000	Under Constr	1961	.....	.....	.....
Ethyl	Baton Rouge, La.	*Methyl Chloride	25,000,000 lbs/yr	.....	Complete	.....	.....	.....	.....
Foster Grant	Baton Rouge, La.	Styrene Monomer	180,000,000 lbs/yr	.....	Under Constr	1961	Staff	Staff	Staff
	Beaumont, Tex.	Polyethylene	.....	.....	Under Constr	1961	SD	SD	SD
Gillring Oil	Fashing, Texas	Sulfur Recovery	10 tons	.....	Under Constr	1961	.....	Graff	Graff
Goliad/Union Oil of Cal.	Ascension Parish, La.	LPG Fractionation	20,000 bbls	.....	Under Constr	.....	.....	B & R	Mid-Valley
Goliad	Lavaca County, Texas	Exp. Gasoline	to 255 MMcf	.....	Under Constr	Oct 1961	.....	Olsen	Olsen
Goodrich Gulf Chemicals	Port Neches, Texas	Polyolefins, High-Density Polyethylene	13,000,000 lbs/yr	.....	Complete	.....	Ziegler	Parsons	Parsons
Goodyear	Beaumont, Tex.	Polyisoprene, Isoprene Polybutadiene	30,000-40,000 tons/yr	.....	Under Constr	Jan 1962	.....	SD	SD
W.R. Grace	Baton Rouge, La.	Polyethylene	.....	.....	Under Constr	1961	.....	.....	.....
	Big Spring, Tex.	Anhydrous Ammonia	60,000 tons/yr	.....	Under Constr	Spring 1962	.....	Foster Wheeler	Foster Wheeler
Gulf Oil	Port Arthur	Delayed Coker	550 tons	.....	Complete	.....	.....	Kellogg	Kellogg
	Mt. Belvieu, Texas	*Ethylene	Over 400,000,000 lbs/yr	.....	Engineering	Mid 1963	.....	.....	.....
Hercules Powder	Lake Charles, La.	Polypropylene	120,000,000 lbs/yr	.....	Under Constr	1961	Staff	.....	Bechtel
Houston Chemical	Beaumont, Tex.	Ethylene Glycol, Ethylene Oxide	8-12,000,000 gals/yr	$12,000,000	Under Constr	1961	SD	SD	SD
		TEL-TML	.....	.....	Complete	.....	.....	FSB	FSB
Humble	Crane County, Texas	*Gas Processing	40 MMcf	.....	Under Constr	Dec 1961	.....	Hudson	Hudson
	Waller County, Texas	*Exp. Ethane Recovery	to 2,517 bbls	.....	Under Constr	Dec 1961	.....	Stearns-Roger	Stearns-Roger
Lyda Hunt-Herbert Trusts	Refugio County, Texas	Gasoline	30 MMcf	.....	Under Constr	1961	.....	Stearns-Roger	Stearns-Roger
Mobil Chemical	Beaumont, Tex.	Ethylene	380,000,000 lbs/yr	.....	Complete	.....	.....	Kellogg	Kellogg
		Exp. Polyethylene	12,500 bbls	$2,500,000	Planning	.....	.....	.....	.....
Mobil Oil	Beaumont, Tex.	Delayed Coking	.....	.....	Complete	.....	.....	Lummus	Lummus
Monsanto Chemical	Gulf Coast Chocolate Bayou, Texas	Styrene Monomer	200,000,000 lbs/yr	$30,000,000	Planning	1961	.....	.....	.....
		Ethylene	500,000,000 lbs/yr	.....	Engineering	1962	.....	Bechtel/Staff	Bechtel/Staff
		Benzene	42,000,000 gals/yr	.....	Engineering	1962	.....	Bechtel/Staff	Bechtel/Staff
		Naphthalene	50,000,000 lbs/yr	.....	Engineering	1962	.....	Bechtel/Staff	Bechtel/Staff
		*Phenol	75,000,000 lbs/yr	.....	Engineering	Summer 1962	Hercules Powder	Kellogg	Kellogg
Pan American Pet.	North Cowden, Texas	Exp. Gas Compression	.....	.....	Under Constr	.....	.....	Staff	B & R
	Old Ocean, Tex.	Exp. Refinery	.....	.....	Engineering	.....	.....	B & R	B & R
Petroleum Chemicals	Lake Charles, La.	Exp. Ethylene	100,000,000 lbs/yr	.....	Planning	1962	.....	Lummus	.....
Petro-Tex Chemical	Houston, Texas	Maleic Anhydride	30,000,000 lbs/yr	.....	Under Constr	.....	SD/Staff	SD	SD
Phillips Chemical	Borger, Texas	Exp. Synthetic Rubber	20,000 tons/yr	.....	Under Constr	.....	.....	.....	.....
	Orange, Texas	Carbon Black	60,000,000 lbs/yr	.....	Complete	.....	.....	Staff	Stearns-Rogers
	Sweeny, Texas	Ethylene	160,000,000 lbs/yr	.....	Under Constr	1961	.....	Braun	Braun
Phillips Petroleum	Sweeny, Texas	Benzene	22,000,000 gals/yr	.....	Under Constr	1961	.....	Procon	Procon
	Freer, Texas	*Gasoline	150 MMcf	.....	Engineering	1962	.....	Dresser	Dresser
	Stephenville, Texas	Natural Gasoline	25,000 MMcf	.....	Under Constr	1961	.....	Staff	Staff
	Abbeville, La.	Natural Gas Liquids	45,000 MMcf	.....	Under Constr	1961	.....	Stearns Roger	Stearns Roger
Pure Oil	Nederland, Tex.	*CO Boiler	160,000 lbs/hr	.....	Under Constr	Spring 1962	.....	Foster Wheeler/Staff	Foster Wheeler
Pure Oil, Atlantic Refining	Nederland, Texas	BTX	137,000 gals	.....	Under Constr	Dec 1961	UOP	UOP/Kellogg/Staff	Kellogg
Rexall Chemical	Odessa, Texas	Polyethylene	120,000,000 lbs/yr	$20,000,000	Under Constr	1961	.....	Fluor	Fluor
Sid Richardson Carbon	Big Spring, Tex.	Furnace Black	50,000,000 lbs/yr	.....	Under Constr	1961	United Carbon	B & R	B & R
Sid Richardson Gasoline	Winkler County, Texas	*Gas Recycling	30 MMcf	$1,000,000	Engineering	Early 1962	.....	Staff/Pona	Pona
Shell Oil	Sheridan, Texas	Gas Cycling	150 MMcf	$1,000,000	Planning	.....	.....	.....	.....
		Amine	.....	$125,000	Engineering	1961	.....	Pona	.....
	Bryans Mill, Cass County, Texas	Gas Sweetening Condensate Stabilization	30 MMcf	.....	Engineering	Late 1961	.....	B & R	B & R
		Sulfur Recovery	120 tons						
	Ysclosksey, La.	Gas Processing	600 MMcf	.....	Under Constr	Early 1962	.....	B & R	B & R

*First appearance in tabulation.

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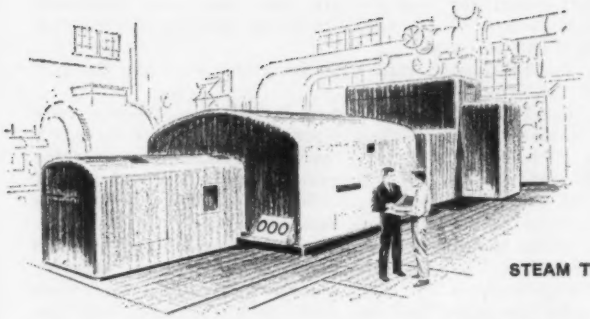
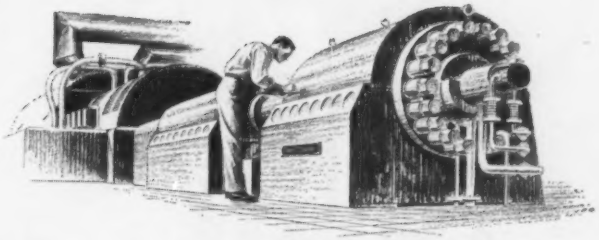
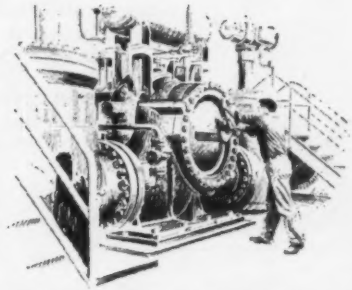


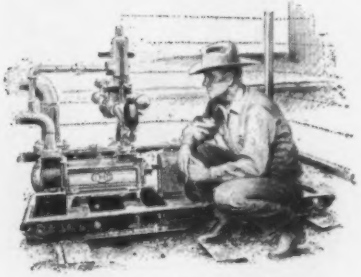
STEAM TURBINES



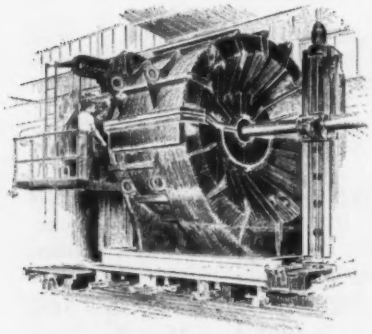
CENTRIFUGAL PUMPS



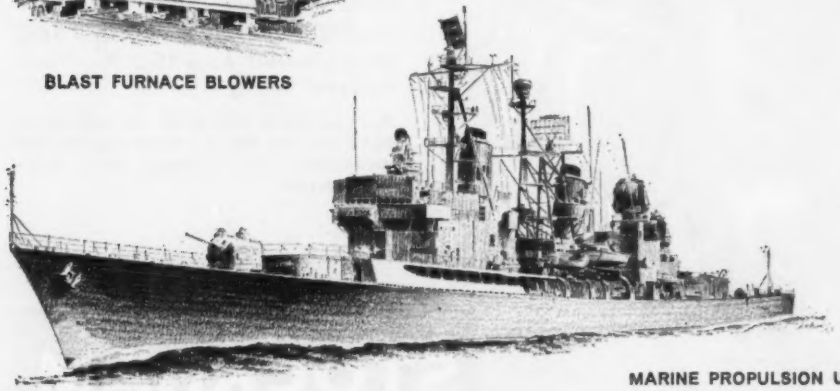
SINGLE- AND MULTI-STAGE COMPRESSORS

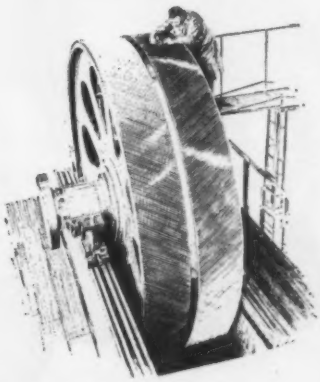


IMO® ROTARY PUMPS



BLAST FURNACE BLOWERS





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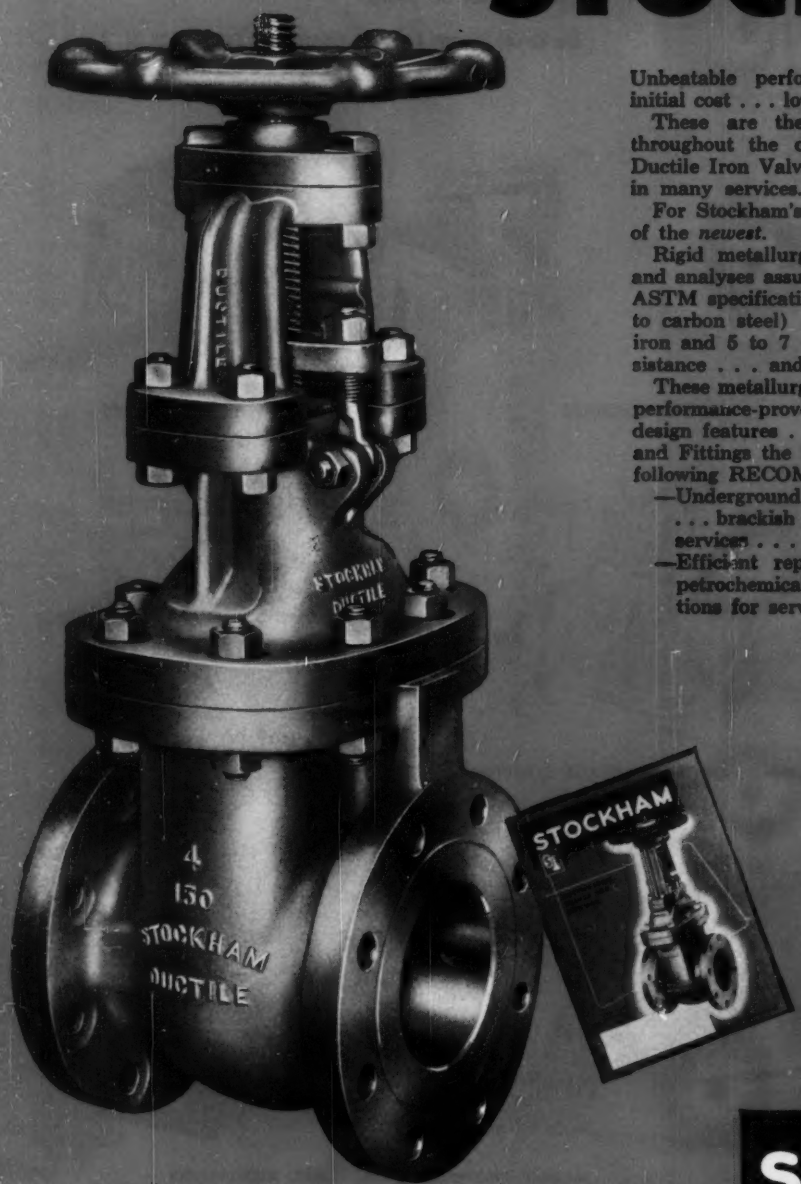

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HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Signal Oil & Gas	Houston	Crude, Vacuum, Vis-breaker, Light Ends	60,000 bbls		Under Constr	Late 1961		B & R	B & R
Sinclair-Koppers	Houston	Ethylbenzene, Styrene	70,000,000 lbs/yr	$6,500,000	Complete		Cosden	Badger Mfg	Badger Mfg
Sinclair Refining	Houston	Crude Still	60,000 bbls		Complete			Braun	Braun
South Louisiana Production	Jeanerette, La.	Butane, Propane, Other LPG			Under Constr				
Sunray Mid-Continent	Church Point, La.	*Cycling Addition			Under Constr	1961		Dresser	Dresser
Suntide Refining	Corpus Christi, Texas	Hydeal	1,000 bbls	$800,000	Complete		UOP	UOP	Staff
		*Gas Desulfurization	7 MMcf		Engineering	1962		Graff	Parsons
		*Paraxylene	15,000,000 lbs/yr	$750,000	Under Constr	Early 1962	Phillips	Parsons	Parsons
		Ethylbenzene	30,000,000 lbs/yr	$1,500,000	Complete		Cosden	Badger Mfg	Badger Mfg
Tenneco Chemical	Houston	*Acetylene	100,000,000 lbs/yr		Engineering	Fall 1962	SBA	Kellogg	Kellogg
Tenneco Oil	Chalmette, La.	Udex Aromatics Extraction	3,100 bbls		Complete		UOP	Badger Mfg	Badger Mfg
		Ethylbenzene	20 MM lbs/yr		Complete		Cosden	Badger Mfg	Badger Mfg
		Catalytic Reforming	6,000 bbls		Complete		Houdry	Houdry/Bechtel	Bechtel
		Orthoxylene	20,000,000 lbs/yr		Complete			Bechtel	Bechtel
	Palacios, Texas	*Exp. Gasoline	to 95 MMcf		Under Constr	Oct 1961		Olsen	Olsen
	La Porte, Texas	*Fractionation			Under Constr	1961		Olsen	Olsen
Texaco	Port Arthur, Texas	Hydrotreater	12,000 bbls		Complete			Fluor	Fluor
		Benzene	30,000,000 gals/yr		Under Constr	Mid 1962			
		*Naphthalene	100,000,000 lbs/yr		Engineering	1962			
	Lamesa, Texas	Natural Gasoline	10 MMcf	$700,000	Under Constr	1961		Pona	Pona
Texas Alkyls	Pasadena, Texas	*Exp. Aluminum Alkyls	to 10,000,000 lbs/yr		Under Constr	Oct 1961		Staff	B & R
Texas-U.S. Chemical	Port Neches Texas	Polybutadiene	20,000 tons/yr		Planning	Early 1963			
Tidewater Oil	Evangeline Parish, La.	*Gas Processing	27 MMcf		Planning	Feb 1962			
Union Carbide	Seadrift, Texas	Ester & Alcohol	100,000,000 lbs/yr		Complete				
		Exp. Petrochemicals			Complete			Staff	B & R
	Brownsville, Texas	Chemical Solvents, Intermediates		$2,500,000	Complete				B & R
U. S. Industrial Chemicals	Houston	Polyethylene	60,000,000 lbs/yr		Planning	Late 1962			
Warren Petroleum	Odessa, Texas	Gas Products	200,000 Mcf		Planning	1962			
		Sulfur	50 tons		Planning	1962			
Wickett Refining	Wickett, Texas	Platformer	1,500 bbls	$350,000	Planning		UOP	J C Hinds	J C Hinds

Rocky Mountain

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
American Oil	Casper, Wyo.	Crude Distillation	37,000 bbls		Complete			Bechtel	Bechtel
El Paso Natural Gas	Lea County, N.M.	Ethane Extraction	650 MMcf		Planning	Late 1961			
Farmers Union Central Exchange	Laurel, Mont.	Fractionator & Stripper Column		$110,000	Complete		UOP	UOP	Sweco
Gas Processors	Patrick Draw Field, Wyo.	Natural Gasoline	20,000 gal		Complete			Staff	Staff
	South Elk Basin, Wyo.	Exp. Natural Gasoline	8,000 Mcf	$160,000	Complete			Staff	Staff
N. C. Ginther	Newcastle, Wyo.	Gasoline	5 MMcf		Engineering	1961		Russell Eng	Staff
Kerr-McGee Oil Industries	Navajo, Ariz.	*Helium Extraction	200 Mcf		Under Constr	Nov 1961			Service Engineering
Phillips Petroleum	Great Falls, Mont.	*Naphtha Feed Hydrotreater	600 bbls		Under Constr	Nov 1961		Litwin	Litwin
		*Catalytic Reforming	600 bbls		Under Constr	Nov 1961		Litwin	Litwin
		*Distillate Hydrotreater	500 bbls		Under Constr	Nov 1961		Litwin	Litwin

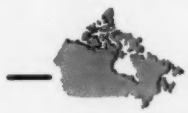
West Coast

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Allied Chemical	El Segundo, Calif.	*Phthalic Anhydride			Under Constr	1962	Chemibau	Parsons	Parsons
Borden Chemical	San Francisco	Formaldehyde	22,500 tons/yr		Under Constr				
Collier Carbon & Chemical, Tidewater Oil	Los Angeles	Naphthalene	50,000,000 lbs/yr		Planning	Early 1962	Union Oil-Cal		
Continental Carbon	Bakersfield, Calif.	Carbon Black	30,000,000 lbs/yr	$2,500,000	Complete			Parsons	Parsons
Dow Chemical	Torrance, Cal.	Polypropylene			Complete				
	Kalama, Wash.	Phenol	36,000,000 lbs/yr		Under Constr	Mid 1962			
Golden Eagle Ref.	Torrance, Calif.	Exp. Refinery	to 30,000 bbls	$35,000,000	Planning	Mid 1963		UOP	
Hercules Powder	Hercules, Calif.	Methanol	8,000,000 gals/yr		Under Constr	1961			
		Formaldehyde	50,000,000 lbs/yr		Under Constr	1961			
Powerine Oil	Santa Fe Springs, Calif.	*Lomax		$2,500,000	Complete		UOP	UOP	Staff
Richfield Oil	Everett, Wash.	Refinery		$50,000,000	Planning	1965			
	Watson, Calif.	Depropanizer			Under Constr	1962		Parsons	Parsons
Shell Oil	Martines, Cal.	Lube Hydrotreater			Complete		Shell	Braun	Braun
	Anacortes, Wash.	*Hydrotreating				Spring 1962		Fluor	Fluor
Standard Oil (Calif.)	Richmond, Cal.	Exp. Polybutene		$3,400,000	Complete			Staff	
		Paraxylene			Under Constr	1961			
		Orthoxylene			Under Constr	1961			
	Carpinteria, Calif.	*Gasoline Recovery	22 MMcf	$500,000	Engineering	Jan 1962		Sweco	Sweco
	Honolulu	Refinery	32,000 bbls	$65,000,000	Under Constr	1962		Staff/Bechtel	Bechtel/Hawiian Dredging
Sunray Mid-Continent	Newhall, Calif.	*Exp. Gasoline	to 70 MMcf		Engineering	1962		Dresser	
Texaco	Los Angeles	CO Boiler	250,000 lbs/yr		Complete			Babcock & Wilcox	C C Moore
Tidewater Oil	Avon, Cal.	Isocracking	20,000 bbls	$20,000,000	Engineering	Mid 1962	Cal Research	Cal Research/ Bechtel	Bechtel
Union Oil	Wilmington, Cal.	Cutter Stock Unifiner			Under Constr	1961	Union	Braun	Braun
Union Carbide	Fontana, Calif.	*Hydrogen			Engineering	Mid 1962	Chemico	Chemico	Chemico
United Carbon	Mojave, Calif.	Carbon Black	175,000 lbs	$5,000,000	Planning	Early 1962			Lummus
Wilshire	Norwalk, Cal.	Refinery Revamp			Complete			Braun	Staff

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Witfield Oil	Watson, Cal.	Detergent Alkylate	.....	.....	Under Constr	Late 1961	Standard-Indiana	Braun	Braun



Canada

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
British American Oil	Clarkson, Ont.	CO Boiler	165,000 lbs/hr	$900,000	Complete	.....	.....	Combustion Engineering/ Staff	Combustion Engineering/ Staff
		*Bio-Oxidation	.....	$170,000	Under Constr	Late 1961	.....	Dorr-Oliver/ Staff	.....
	Montreal	*Cyclohexane	15,000,000 gals/yr	$4,000,000	Engineering	1962	UOP	UOP/Kellogg/ Staff	.....
Brockville Chemicals	Maitland, Ont.	Hydrogen	15 MMcf	.....	Under Constr	1961	Texaco/ Power-Gas/ Benfield	Power-Gas	Power-Gas
		*Synthetic Nitrogen, *Ammonium Nitrate, *Nitrogen Solutions, *Anhydrous Ammonia	.....	$17,000,000	Engineering	1961	Chemico	Chemico/ERI	Chemico
		*Partial Oxidation Gasification	15 MMcf	$1,800,000	Under Constr	1961	.....	Power-Gas	Power-Gas
Canadian Chemicals	Edmonton, Alta.	Exp. Refinery	.....	$4,000,000	Complete	.....	.....	.....	.....
Carstairs-Crossfield Operators	Carstairs, Alta.	Gas Processing	130 MMcf	$4,000,000	Under Constr	Nov 1961	.....	Fluor	Fluor
Colombian Carbon (Canada)	Hamilton, Ont.	Carbon Black	40,000,000 lbs/yr	.....	Under Constr	1961	Staff	B & R	.....
Consumers Cooperative Refineries	Regina, Sask.	Exp. Crude	to 22,500 bbls	$400,000	Under Constr	Nov 1961	.....	UOP/Staff	Treco
		Exp. Cat Cracking	to 9,000 bbls	$300,000	Under Constr	Nov 1961	UOP	UOP/Staff	.....
Dominion Rubber	Edmonton, Alta.	Petrochemicals	.....	.....	Engineering	1961	Staff	B & R	B & R
Dominion Tar & Chemical	Toronto, Ont.	Phthalic Anhydride	22,000,000 lbs/yr	.....	Engineering	Early 1962	Sherwin-Williams	Canadian Badger	Canadian Badger
Dow-Canada	Ft. Saskatchewan	Pentachlorophenol	.....	.....	Under Constr	1961	Staff	B & R	B & R
		Glycols, Ethanolamines	.....	.....	Under Constr	1961	.....	.....	.....
	Ladner, B. C.	Phenol	.....	.....	Under Constr	1961	.....	.....	.....
Gas Trunk Line of British Columbia	Boundary Lake Field, B.C.	*Gas Sweetening, LPG Recovery	10 MMcf	$385,000	Under Constr	Late 1961	.....	Black, Sivalls & Bryson	Black, Sivalls & Bryson
Golden Eagle Refining	St. Johns, Nfld.	Refinery: Crude Topping, Visbreaking, Platforming, Unifining	7,500 bbls	$5,000,000	Under Constr	1961	UOP	Sweco	Lundrigan
Innisfail Operators Committee	Innisfail Field, Alta.	Sulfur Recovery	80 tons	.....	Planning	.....	.....	.....	.....
		Gas Treating	8.7 MMcf	.....	Planning	.....	.....	.....	.....
Irving Refining	Saint John, New Brunswick	Gas Treating, Sulfur Recovery	150 MMcf	$1,300,000	Engineering	Dec 1961	.....	Parsons	Parsons
Jefferson Lake Petrochemicals	Calgary, Alta.	Sulfur Recovery	875 tons	.....	Complete	.....	.....	.....	Parsons
	Coleman, Alta.	Sulfur Recovery	380 tons	$1,250,000	Under Constr	Dec 1961	Parsons	Parsons	Parsons
North Star Oil	St. Boniface, Man.	*Unifiner-Platformer	2,700 bbls	.....	Complete	.....	UOP	Procon	Procon
Pan American Petroleum, Canadian Fina	Whitecourt, Alta.	Gas Injection	175 MMcf	.....	Engineering	Late 1961	.....	B & R	B & R
		Gas Sweetening							
		LPG Recovery							
		Sulfur Recovery	640 tons	.....	.....	.....	.....	.....	.....
Petrogas Processing, Jefferson Lake Petrochemicals	Balzac, Alta.	Gas Gathering, Gas Treating	100 MMcf	$12,500,000	Under Constr	Dec 1961	.....	Parsons	Parsons
		*Condensate Recovery	2,200 bbls	.....	.....	.....	.....	.....	.....
		Sulfur Recovery	860 tons						
Polymer	Sarnia, Ont.	Polybutadiene	20,000 tons/yr	$9,000,000	Under Constr	Fall 1962	Karl Ziegler/ Goodrich-Gulf	Catalytic Canada	Catalytic Canada
		*Butadiene Extraction	.....	$7,500,000	Under Constr	1961	.....	Fluor	Fluor
Regent Refining	Port Credit, Ont.	Benzene	.....	$2,000,000	Complete	.....	UOP	UOP/Bechtel	Canadian Bechtel
		Waste Water Disposal	.....	$450,000	Complete	.....	.....	Staff/Bechtel	Canadian Bechtel
Shawinigan Chemicals	Varennes, Que.	*Ethylene	100,000,000 lbs/yr	.....	Engineering	Late 1962	.....	Kellogg	Kellogg
Sherritt Gordon Mines	Ft Saskatchewan	*Urea	.....	.....	Engineering	.....	DSM	Braun	Braun
Shell Oil (Canada)	Trafalgar Township Ont.	*Refinery	31,000 bbls	.....	Engineering	1963	.....	.....	.....
Union Carbide Canada	Newton, B.C.	*Polyethylene Film	2,000,000 lbs/yr	.....	Under Constr	Early1962	.....	.....	Dominion Construction
Westcoast Transmission	Coleman, Alta.	Gas Processing	75 MMcf	$10,000,000	Under Constr	Late 1961	.....	Canadian Bechtel	Canadian Bechtel
Western Leaseholds	near Calgary, Alta.	Gas Gathering, Processing	80 MMcf	$6,200,000	Under Constr	Late 1961	.....	Stearns Roger	Stearns Roger

Latin America

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ARGENTINA									
Argentine Government	Santa Fe	Naphtha Reforming, Aromatics Extraction	6,300 bbls	.....	Planning	.....	.....	.....	.....
	Mendoza	Topping, Delayed Coking, Catalytic Cracking	28,300 bbls	$30,000,000	Under Constr	Nov 1961	Kellogg	Kellogg	Kellogg
	Salta	Naphtha Reforming	3,150 bbls	.....	Planning	.....	.....	.....	.....
	Buenos Aires	Topping, Naphtha Reforming, Lube Oil	20,000 bbls	.....	Planning	.....	.....	.....	.....
Cabot Argentina S.A.I.C.	Buenos Aires	Carbon Black	13,000 tons/yr	$4,000,000	Under Constr	Early 1962	Cabot	Cabot	.....
Diadema Argentina Shell	Buenos Aires	Crude Still, Feed Preparation, Stabilizer	33,000 bbls	.....	Under Constr	Early 1962	.....	.....	McKee
		Cat Cracker	16,000 bbls	.....	Under Constr	1963	.....	.....	.....
Esso S.A.P.A.	Campana	Cat Cracker	8,500 bbls	.....	Under Constr	End 1961	Esso	Esso/Kellogg	Tecnastar
		Propane Dewaxing	2,000 bbls	.....	Planning	.....	Esso	Esso/Staff	.....
Hooker Chemical Atanor	Rio Tercero	Phenol	25 tons	.....	Under Constr	1962	.....	Fish	Fish

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what ethylene producers are doing about increasing capacity

The domestic demand for ethylene, largest-volume olefinic raw material produced by the petrochemical industry, continues to grow at a substantial rate. Over a four-year period (1955-'59), production capacity for ethylene skyrocketed from a little over three billion to a 5.6 billion pounds per year. And the plateau for this fast growth rate is nowhere in sight. Conservative estimates indicate that by 1965, ethylene capacity in the U.S. will have reached a rewarding 7.1 billion lbs./year.

Giving life to this tremendous growth in production capacity is the cracking furnace. In many petrochemical plants throughout the United States, the cracking furnaces were designed and built by Selas.

The record shows that Selas supplied 47.5% of the total ethylene production capacity, from all sources, in the 1955-'59 period. This represented 79% of the furnaces designed and constructed by firms other than the petrochemical companies' own engineering staffs. The 31 Selas GRADIATION® furnaces installed from '55 to '59 corresponded to a total ethylene cracking capacity of 1.2 billion pounds. In 1960, Selas sold or installed cracking furnaces representing additional ethylene production capacity of 0.96 billion pounds or 80% as much capacity as Selas sold and installed in the previous four years.

The acceptance of GRADIATION furnaces for ethylene production is exemplified by repeat orders. In the past eight years, one leading ethylene producer has —on nine different occasions—purchased a total of 17 Selas GRADIATION cracking furnaces. Two other petrochemical plants have each installed 11 furnaces. Each made four separate purchases to reach their present production capacity.

As the human heart adjusts to the varying demands of the body, so are Selas GRADIATION furnaces adjusted to changes in ethylene production dictated by competitive pressures. The Selas furnace, for example, permits cracking of ethane, propane, butane or naphthas by simple, easily-made adjustments in the patented radiant heating pattern. This flexibility—combined with the uniformity of heating and controllability of Selas furnaces—allows ethylene producers to obtain optimum yields from varying feed stocks, and to balance their production economically against changing marketing situations.

A Selas engineer is prepared to discuss your processing needs with you. For this service—without cost or obligation to you—or for a copy of Bulletin 1043—"GRADIATION Heating for Petroleum and Chemical Processing," write to the Fluid Processing Division.

SELAS

HEAT AND FLUID PROCESSING ENGINEERS

DEVELOPMENT • DESIGN • CONSTRUCTION

SELAS CORPORATION OF AMERICA
710 Dreshertown Road, Dresher, Pa.

EUROPEAN SUBSIDIARY: Selas Corporation of America, European Div., S.A., Pregny, Geneva, Switzerland.

INTERNATIONAL AFFILIATES—Australia, Benelux, Canada, England, France, Germany, Italy, Japan, Portugal, Spain.

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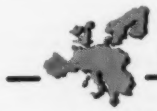
HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Hydrocarbon-Argentina	San Lorenzo	Gasoline Benzene	11,000 bbls 7000 bbls	$13,500,000	Planning	1963	Hydrocarbon/ Atlantic	Hydrocarbon	Staff
Petroquimica Argentina	San Lorenzo	Synthetic Rubber, cis-Polybutadiene	45,000 tons/yr	$70,000,000	Engineering	Mid 1963	.....	Fish	Fish
BRAZIL									
Firestone Tire & Rubber	Near Recife-Pernambuco	*Polybutadiene	30,319 tons/yr	.....	Engineering	.....	Staff	Lummus	Lummus
Industria Quimica Productos Ftalicos (W. R. Grace)	Ftalicos	*Exp. Phthalic Anhydride	to 3,000 tons/yr	.....	Under Constr	1961	.....	.....	.....
North American Solvay	Sao Paulo	Ethylene Purification	20 tons	.....	Under Constr	Fall 1961	.....	Hydrocarbon	Hydrocarbon/ SETAL
Pernambuco State	Pernambuco	Synthetic Rubber	40,000 tons/yr	.....	Planning	.....	.....	.....	.....
Petroleo Brasileiro	Duque De Caxias—Rio de Janeiro	Refinery	90,000 bbls	$60,000,000	Under Constr	1961	Houdry/ UOP	Foster Wheeler	Petrobras Montreal
	Duque De Caxias-Do Rio de Janeiro	Synthetic Rubber	40,000 tons/yr	.....	Under Constr	1962	.....	Blaw/Knox	.....
	Cubatao-Sao Paulo	Cat Reformer Aromatics Extraction Ethane Cracking	12,000 bbls 4,750 bbls 3.77 MMcf	$10,000,000	Engineering	1963	Houdry/ UOP	Promon	.....
	Catu-Mataripe Bahia	*Natural Gasoline, Gas Collection, Gas Absorption	50 MMcf	$7,000,000	Under Constr	1962	.....	Hudson	Staff/SETAL
	Porto Alegre-R. G. Sul	*Refinery	25,000 bbls	.....	Planning	1964	.....	.....	.....
	Belo Horizonte-Minas Gerais	*Refinery	25,000 bbls	.....	Planning	1965	.....	.....	.....
	Fortaleza-Ceara	*Asphalt	80,000 tons/yr	$1,000,000	Planning	End 1962	.....	.....	.....
	Madre De Deus-Bahia	*Asphalt	80,000 tons/yr	$1,000,000	Planning	End 1962	.....	.....	.....
Union Carbide International	Cubatao-Santos	Exp. Polyethylene	12,000 tons/yr	.....	Engineering	Mid 1962	Union Carbide	B & R	B & R
CHILE									
Empresa Nacional del Petroleo	Magallanes	Natural Gasoline	100 MMcf	$5,000,000	Under Constr	Jan 1962	.....	Hudson	Staff
COLOMBIA									
Amoniaco Del Caribe S.A.	Cartagena	Ammonia Nitric Acid	300 tons 150 tons	$13,000,000	Engineering	Mid 1962	.....	C & I/Girdler	C & I/Girdler
Colombian Petroleum	.....	Gasoline	40 MMcf	$450,000	Engineering	1961	.....	Pona	Staff
Empresa Colombiana de Petroleos	Barrancabermeja	*Exp. Refinery: Vacuum Distillation Phenol Extraction Deisopentenizer	 9,150 bbls 2,000 bbls	.....	Engineering	.....	.....	Kellogg	Kellogg
Gas Natural Colombiano, S.A.	Cicuco	Gas Compressor	.....	.....	Engineering	1961	.....	B & R	.....
COSTA RICA									
Fertilizantes de Centro America (Ferticas), et al	.....	Nitrogen, Potash & Phosphorus Fertilizers, Urea	650 tons	$10,000,000	Planning	.....	.....	.....	.....
EL SALVADOR									
Esso Standard S.A.	Acajutla	Refinery	.....	.....	Engineering	1962	.....	Parsons	Parsons
Refineria Shell de El Salvador	Acajutla	Refinery	10,000 bbls	.....	Under Constr	1962	.....	Fluor	Fluor
GUATEMALA									
Refineria Petrolera de Guatemala, et al	Matias de Galvez	Refinery	12,000 bbls	.....	Planning	.....	.....	.....	.....
MEXICO									
Celanese Mexicana S.A.	Taluca	Nylon Polymer	14,000 lbs	$3,000,000	Under Constr	Dec 1961	Firestone/ Zimmer	Day & Zimmerman	Day & Zimmerman
Fertilizantes del Bajio S. A.	Salamanca	Urea	187 tons	.....	Planning	Late 1962	Lonza/ Lummus	Lummus	Lummus
Negromex, S. A.	Salamanca	Carbon Black	33,000,000 lbs/yr	$4,000,000	Engineering	1962	Phillips	Pona	.....
Pemex	Minatitlan	Anhydrous Ammonia	200 tons	$8,000,000	Under Constr	1961	.....	Fluor	Fluor
		Crude	50,000 bbls		Engineering	1961	UOP	Fluor	Fluor
		Cat Reformer	.....	$23,000,000	Under Constr	1961	UOP	Fluor	Fluor
		Udex	16,000 bbls		.....	.....	.....	.....	.....
		BTX	4,800 bbls		.....	.....	UOP	.....	.....
		Hydrar	500 bbls						
		Alkar	200 bbls	$5,000,000	Engineering	Late 1961	UOP	Fluor	Fluor
		Hydeal	2,000 bbls						
	Salamanca	Anhydrous Ammonia	200 tons	$8,000,000	Under Constr	Late 1961	.....	Lummus	Lummus
		Topping	40,000 bbls						
		Cat Cracker	25,000 bbls	$13,000,000	Under Constr	Late 1961	.....	Lummus	Lummus
		Grease	25 tons	$2,100,000	Under Constr	1961	.....	McKee	McKee
	Coatzacoal COS	Ethylene	100,000,000 lbs/yr						
		Ethylene Dichloride	.....						
		Ethyl Chloride	.....	$10,000,000	Engineering	Late 1962	.....	Lummus	Lummus
		Ethylene Dibromide	.....						
		TEL	24,000,000 lbs/yr	.....	.....	.....	.....	H & G	H & G
		Vinyl Chloride	10,000 tons/yr	$3,000,000	Engineering	Mid 1963	.....	.....	Lummus
	Ciudad Madero	Recovery Ethylene	1,000 bbls						
		Butadiene	1,000 bbls	$15,400,000	Under Constr	.....	.....	.....	.....
		Styrene	325 bbls		.....	.....	.....	McKee	McKee
		Dodecyl Benzene	45 tons		.....	.....	Phillips	.....	.....
		SBR Rubber	20,000 tons/yr	$8,300,000	Under Constr	Late 1961	Polymer	McKee	McKee
	Poza Rica	Topping	15,000 bbls	$5,000,000	Under Constr	1961	.....	McKee	McKee
	Atzcapozalco	Polyethylene	25,000,000 lbs/yr	$8,000,000	Under Constr	Late 1961	ICI	Simon Carver/ McKee	Simon Carver/ McKee
	La Venta	Absorption	150 MMcf						
	Ciudad Pemex	Exp. Absorption	to 500 MMcf	$7,500,000	Under Constr	Late 1961	.....	Hudson	Hudson
	Reynosa	Exp. Absorption	to 500 MMcf	$3,500,000	Under Constr	Late 1961	.....	Hudson	Hudson
NICARAGUA									
Esso Standard S.A.	.....	Refinery	.....	.....	Engineering	1962	.....	Parsons	Parsons
PANAMA									
Golden Eagle Refining-Panama	Portobelo	Refinery	55,000 bbls	$57,000,000	Under Constr	Oct 1962	.....	McKee	McKee
		Aromatics	13,000 bbls		Under Constr	April 1962	UOP	McKee	McKee
Refineria Panama, S.A.	Las Minas Bay Colon	Refinery; Petrochemicals	55,000 bbls	$45,000,000	Under Constr	Dec 1961	.....	Bechtel	Bechtel
TRINIDAD									
Shell Trinidad	Point Fortin	Distillation Revamp	14,000 bbls	.....	Under Constr	1961	.....	.....	.....
VENEZUELA									
Mene Grande Oil	Eastern Venezuela	Compressor Stations	.....	.....	Engineering	.....	.....	B & R	.....
United Carbon Venezuela	Valencia	Carbon Black	20,000,000 lbs/yr	$4,000,000	Planning	Early 1962	.....	Lummus	Lummus
Venezuela-Gulf Refining	Puerto la Cruz	HF Alkylation	2,200 bbls	.....	Under Constr	Late 1961	.....	Foster Wheeler	Foster Wheeler

*First appearance in tabulation.



Europe

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRIA									
Osterreichische Mineraloelver-Waltung	Schwechat, near Vienna	Cat Cracker	10,000 bbls	.....	Under Constr	1962	UOP	Comprimo	Voest
		Feed Preparation	30,000 bbls	.....	Engineering	1962	.....	UOP	.....
		*Gasoil Hydrogenation	250,000 tons/yr	.....	Engineering	Oct 1962	Shell	Lurgi	Lurgi
		*Propylene-Propane Splitting	700 bbls	.....	Engineering	Sept 1962	.....	Lurgi	Lurgi
Vienna Gasworks	Vienna	Cat Reformer	18.2 MMcf	.....	Engineering	1961	.....	Otto	Otto
BELGIUM									
Albatros	Antwerp	Exp. Refinery	.....	$2,000,000	Under Constr	1961	.....	Badger N V	Badger N V
Cobenam, S.A.	Antwerp	Ethylene	.....	.....	Engineering	1961	S & W	S & W	.....
		Polyethylene	.....	.....	Under Constr	Late 1961	Union Carbide	George Wimpey/ B & R/Staff	B & R/Others
Raffinerie Belge de Petroles	Antwerp	LPG & Sulfur Recovery	.....	$1,900,000	Under Constr	1961	.....	Technip	Oxy France/ Technip
Societe Chimique de Selzaete	Zelzaete	Maleic Anhydride	.....	.....	Under Constr	Spring 1962	SD	SD/SFST	SFST
Societe Industrielle Belge des Petroles	Antwerp	Crude Distillation	100,000 bbls	.....	Under Constr	Late 1962	.....	Foster Wheeler	Foster Wheeler
		Catalytic Reformer	9,000 bbls	.....	Under Constr	Late 1962	.....	Foster Wheeler	Foster Wheeler
		Hydrofiner	10,000 bbls	.....	Under Constr	Late 1962	.....	Foster Wheeler	Foster Wheeler
		Sulfur Recovery	60 tons	.....	Under Constr	Late 1962	.....	Foster Wheeler	Foster Wheeler
Union Chemique Belge	Ghent	Phthalic Anhydride	5,000 tons/yr	$2,000,000	Under Constr	1961	Sherwin-Williams	Badger N V	Badger N V
BULGARIA									
Technoimport	Dewnja	Acetylene	35 tons	.....	Engineering	1962	Knapsack-Grie-sheim	Uhde	Chemiebau Zieren
DENMARK									
Dansk-Norsk Kvaelstoffabrik	Copenhagen	*Nitric Acid	30.9 tons	.....	Under Constr	Mid 1963	Uhde	Uhde	Uhde
Dansk Veedol	Kalundborg	Refinery	20,000 bbls	.....	Under Constr	1961	.....	Foster Wheeler	Foster Wheeler
Gulf Oil	Stigsnaes	*Refinery	30,000 bbls	.....	Engineering	End 1962	.....	Kellogg	Kellogg
Imperial Chemical Industries	Copenhagen	Polyethylene	.....	$11,200,000	.....	.....	ICI	.....	.....
Maersk	Copenhagen	Ethylene	.....	.....	.....	.....	.....	S & W	.....
ENGLAND									
Alchemy	Belvedere	Maleic Anhydride	.....	.....	Under Constr	1961	.....	Petrocarbon	Staff/ Petrocarbon
British Petroleum	Kent	Prefractionation	236,000,000 lbs/yr	.....	Under Constr	1962	.....	Badger Ltd	Wimpey
		Paraxylene	1,400 tons/yr	.....	Under Constr	April 1962	.....	Bechtel	Wimpey
British Petroleum/ California Chemical	Kent	Orthoxylene Ethylbenzene Paraxylene	21,000 tons/yr 16,000 tons/yr 14,000 tons/yr	$19,600,000	Under Constr	1962	Cal Research	Badger Ltd	Wimpey
East Midlands Gas Board	Grimesthorpe	Catalytic Oil Gasification	10 MMcf	.....	Under Constr	Oct 1962	Onia Gegi	H & G	H & G
	Dinnington	Catalytic Oil Gasification	3.5 MMcf	.....	Under Constr	Late 1961	Onia Gegi	H & G	H & G
Esso Petroleum	Fawley	Exp. Petrochemicals	.....	.....	Under Constr	1961	Esso	Foster Wheeler	Foster Wheeler
		Butyl Rubber	30,000 tons/yr	$14,000,000	Engineering	1962	.....	Foster Wheeler	Foster Wheeler
Grange Chemical	Hull	Phthalic Anhydride	15,000 tons/yr	.....	Under Constr	1962	Cal Research	Badger Ltd	Badger Ltd
Imperial Chemical Industries	Severnside	Ethylene Oxide	66,000,000 lbs/yr	.....	Under Constr	Winter 1961	SD	SD	.....
Midland Gas Board	Birmingham	*Sulfur Recovery	26.4 tons	.....	Engineering	1962	Parsons	Parsons-Powergas	Parsons-Powergas
Mobil International	Coryton	Exp. Crude	to 46,500 bbls	$2,000,000	Engineering	1962	.....	.....	.....
Monsanto	Newport	Maleic Anhydride	15,000,000 lbs/yr	.....	Under Constr	.....	SD	SD	SD
North Eastern Gas Board	Whitby	Refinery	75,000 bbls	.....	Planning	.....	.....	.....	.....
North Western Gas Board	Ellesmere Port	Gas Reforming	15 MMcf	.....	Under Constr	Late 1961	Onia Gegi	H & G	H & G
	Partington	Gas Reforming	12 MMcf	.....	Under Constr	Late 1961	Onia Gegi	H & G	H & G
Shell Chemical	Carrington	Ethylene	.....	.....	Planning	.....	.....	Lummus	Lummus
Shell Refining	Stanlow	Platformer	6,700 bbls	.....	Planning	1963	.....	.....	.....
	Shell Haven	Isopentane	3,800 bbls	.....	Planning	1963	.....	.....	.....
South Eastern Gas	Isle of Grain	Hydrogen	18 MMcf	.....	Complete	.....	.....	Woodall-Duckham	Woodall-Duckham
Union Carbide	Fawley	Ethylene Oxide & Derivatives	.....	.....	Under Constr	.....	.....	.....	.....
West Midlands Gas Board	Birmingham	Cat Reformer	5 MMcf	.....	Engineering	1962	Otto	Simon-Carves	Simon-Carves
	Stoke on Trent	Light Distillate Gasification	8 MMcf	.....	Engineering	1962	Onia Gegi	H & G	H & G
Woodall Duckham	Fulham	Producer Gas	15 MMcf	.....	Under Constr	Oct 1961	H & G	H & G	H & G
EIRE									
Alliance & Dublin Consumers Gas	Dublin	Catalytic Oil Gasification	.....	.....	Engineering	1962	.....	Power-Gas	Power-Gas
FINLAND									
Neste Oy	Naantali	Exp. Refinery: Desalting, Crude Distillation	24,000 bbls	.....	Under Constr	1962	Howe-Baker	Lummus	.....
		Cat Reformer	3,000 bbls	.....	Under Constr	1962	Sinclair	Lummus	.....
		Hydrodesulfurization	6,000 bbls	.....	Under Constr	1961	Shell	Lummus	.....
Typpi Oy	Oulu	Exp. Ammonia, Nitric Acid	60 tons	.....	Engineering	Late 1962	Linde/ Pintsch-Bamag/ Uhde	Linde/Pintsch-Bamag/Uhde/ Staff	Linde/Pintsch-Bamag
		*Ammonia	132 tons	.....	Engineering	1962	Uhde	Uhde	Uhde
FRANCE									
Ammonia	Vendin-La-Weille	Ammonium Nitrate	150 tons	.....	Engineering	.....	SBA	SBA	SBA
Antar-Petroles del'Atlantique	Donges	Crude Topping	75,000 bbls	.....	Under Constr	1961	.....	Technip	Technip
		Gasoline & Aromatics Super-fractionation	163,000 gals	.....	Under Constr	March 1962	.....	Technip	.....
Compagnie Francaise des Matieres Colorantes	Villers-St.-Paul	Phthalic Anhydride	.....	.....	Under Constr	Late 1961	SD	SD/SFST	SFST
Compagnie Francaise des Petroles/ Compagnie Francaise de Raffinage	Strasbourg	Refinery	70,000 bbls	.....	Planning	.....	.....	.....	.....
	Gonfreville l'Orcher	Platforming	21,200 bbls	.....	Engineering	March 1963	UOP	Technip	Staff
		Cat Reforming	15,000 bbls	.....	Planning	1963	.....	.....	.....
		Ethylene, Steam Cracking	50,000 tons/yr	.....	Planning	1963	.....	.....	.....

*First appearance in tabulation.

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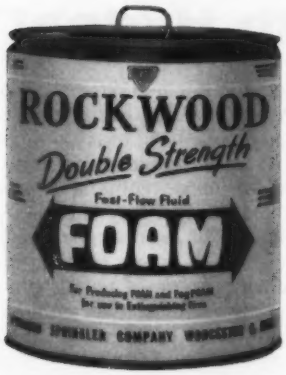

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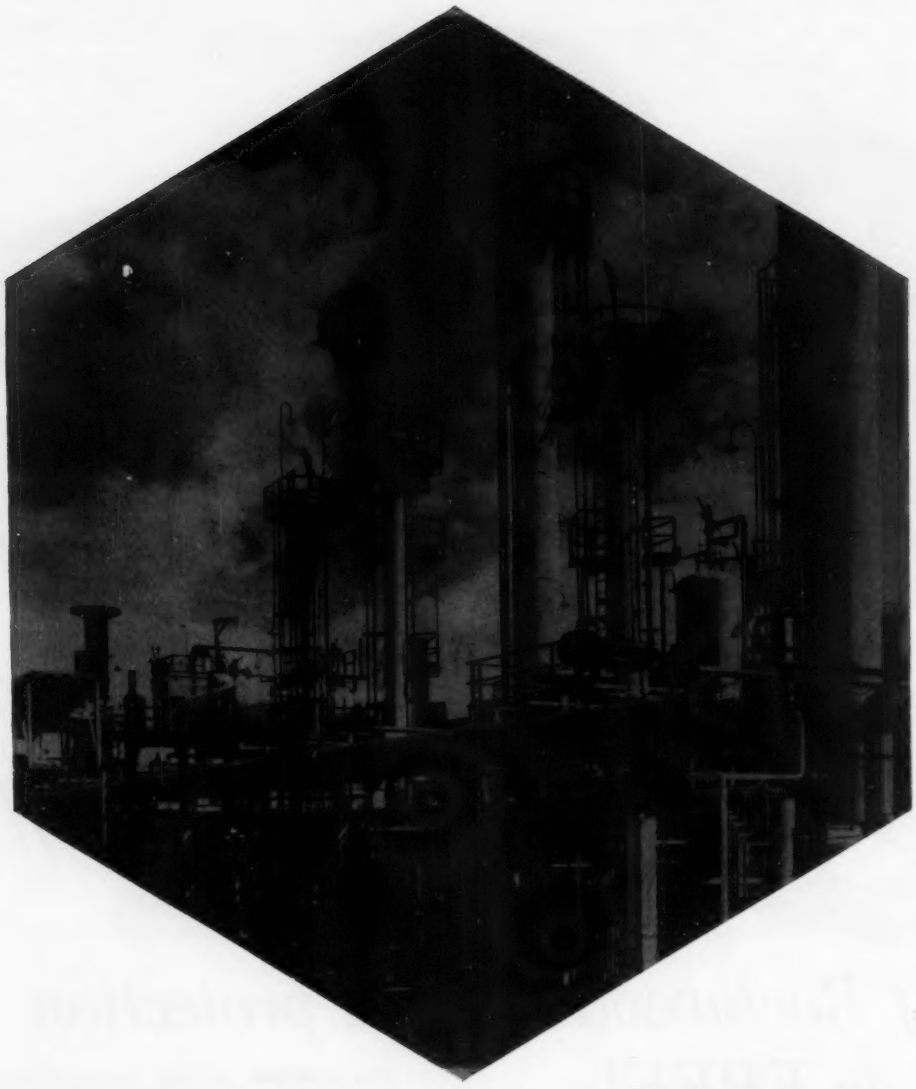

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UNIVERSAL OIL PRODUCTS COMPANY
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HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Compagnie Rhenane de Raffinage	Strasbourg	Refinery	70,000 bbls	.....	Engineering	Mid 1963	.....	Bechtel/SPIE Serete	Bechtel/SPIE Serete
Esso Francaise	Port Jerome	Aromatics Extraction	.....	.....	Under Constr	Early 1962	.....	Foster Wheeler	Foster Wheeler
Ethyl Synthese	Lillebonne	Monomer Styrene	25 to 30,000 tons/yr	.....	.....	.....	Koppers	SBA	.....
Esso Standard	Port Jerome	Lube Hydrofiner	4,000 bbls	.....	Under Constr	1961	Esso	Esso	Lummus
		Paraxylene, Orthoxylene, Solvents	52,000 tons/yr	.....	Under Constr	1962	Esso	Lummus Esso	Foster Wheeler
		Propylene	29,000 tons/yr	.....	Engineering	1962	Esso	Esso	.....
Firestone France S.A.	Port Jerome	Polybutadiene	.....	.....	Under Constr	1961	.....	Lummus	Lummus
Houillerse du Bassin de Lorraine	Carling	Nitric Acid	.....	.....	Engineering	.....	SBA	SBA	SBA
Mekog	Pernis	Ammonium Nitrate Neutralisation & Concentration	.....	.....	.....	.....	SBA	SBA	Staff
Mobil Oil	Gravenchon	Exp. Lube	to 3,500 bbls	$5,200,000	Under Constr	Mid 1962	.....	Foster Wheeler	Mobil Oil Francaise
Naphthachimie	Lavera	Exp. Butadiene Recovery	8,000 tons/yr	.....	Planning	.....	.....	Foster Wheeler	Foster Wheeler
		Polyisobutene	.....	.....	Engineering	1961	Cosden	Badger France	Badger France
		Propylene	.....	$1,000,000	Under Constr	1961	.....	Badger NV/ Badger France	Badger France
Pierrefitte, Ste. Generale d'Engrais & Produits Chimiques	Pierrefitte-Nestalas	Ammonium Nitrate Treating	600 tons	.....	Under Constr	1961	Pierrefitte	Solemca	Staff
Polymer S.a.r.L	Strasbourg	Specialty Rubber	.....	$10,000,000	Engineering	1962	Polymer	Badger NV/ Badger SarL	Badger NV/ Badger SarL
Progil Electrochemie	Pont de Claix	Bisphenol	5,513 tons	.....	Under Constr	1961	Staff	.....	Lummus
Proizvodnja	Lendava	Synthesis Gas	.....	.....	.....	.....	SBA	SBA/TOPSOE	RAMA
Reichhold-Beckacite	Niort	Maleic Anhydride	.....	.....	Under Constr	Spring 1962	.....	SD/SFST	SFST
Rhone-Poulenc	Lavera	Acetaldehyde	.....	.....	Planning	.....	Hoechst	Uhde	Uhde
Societe de La Raffinerie de Strasbourg	Strasbourg	*Atmospheric Distillation	82,000 bbls	.....	Engineering	Early 1963	MHW	MHW	PIC Engineering
		*Gas Treating	7,000 bbls	.....	Engineering	1963	UOP	PIC Engineering/MHW	.....
Societe des Produits d'Aquitaine	Chimique Lacq	Synthetic Ammonia	200 tons	$6,000,000	Engineering	1961	.....	Chemico/ Solemca	Chemico/ Solemca
		Acetylene from Nat. Gas	75 tons	.....	Under Constr	.....	BASF	BASF/Heurtey	Heurtey
Societe Francaise des Petroles/BP	Dunkerque	Lube Hydrofinisher	3,100 bbls	.....	Under Constr	1961	Staff/BP	Staff/BP	.....
		Topping	2,000 tons	.....	Under Constr	1961	Staff/BP	Staff/BP	.....
	Lavera	Bitumen	100,000 tons/yr	.....	Complete	.....	.....	Technip/ Lummus	Technip/ Lummus
Soc. National des Petroles D'Aquitaine	Lacq	Desulfurization	175 MMcf	.....	Complete	.....	.....	Technip	Staff
		Sulfur Recovery	1,100 tons	.....	Under Constr	1961	.....	Parsons & Heurtey	Staff
		Natural Gasoline	120 MMcf	.....	Under Constr	1961	.....	Lummus	Staff
		DEA Washing	140 MMcf	$1,000,000	Under Constr	1961	.....	Technip	Staff
		Preliminary Desulfurization	350 MMcf	.....	Complete	.....	.....	Technip	Staff
		Platforming	2,700 bbls	.....	Engineering	July 1962	UOP	Technip	Staff
		Hydrogen	5,300 Mcf	.....	Engineering	July 1962	TOPSOE	Technip	Staff
		Benzene	.....	.....	Under Constr	1962	UOP	Parsons/ Heurtey	Staff
		Cyclohexane	20,000 tons/yr	.....	Engineering	1962	.....	Technip	Staff
		Hydrodesulfurization	2,900 bbls	.....	Engineering	1962	.....	Foster Wheeler	Staff
Societe Nationale des Petroles d'Aquitaine, El Paso Natural Gas, Societe Nationale REPAL	Lacq	Isoprene	1 ton	.....	Engineering	.....	Institute Francias du Petrole	Technip	Technip
Soc. Vinylace	Lacq	Vinyl Chloride	.....	.....	Planning	.....	.....	.....	.....
Union Industrielle des Petroles	Ambes	*Platforming	3,000 bbls	.....	Engineering	1963	UOP	Technip	Staff
United Carbon	Port Jerome	Carbon Black	25,000 tons/yr	.....	Under Constr	1961	United Carbon	Solemca	Compagnie Francaise
	Rouen	Carbon Black	50,000,000 lbs/yr	$5,000,000	Planning	1961	.....	.....	.....
EAST GERMANY									
DIA Chemie Ausruestung Berlin	Leuna	Ethylene Aromatics	40,000 tons/yr	$12,000,000	Under Constr	1962	Petrocarbon	Petrocarbon/ H & G	Staff/H & G
Leuna-Werk Walter Ulbricht	.....	Urea	.....	.....	Planning	.....	.....	.....	.....
		Ammonium Nitrate	.....	.....	Planning	.....	.....	.....	.....
		Exp. Nitrogen	to 400,000 tons/yr	.....	Planning	1965	.....	.....	.....
Piersteritz Nitrogen	.....	Exp. Nitrogen	to 20,000 tons/yr	.....	Planning	1961	.....	.....	.....
WEST GERMANY									
Badische Anilin & Sod. Fab.	Ludwig-Shafen	Phthalic Anhydride	35,000,000 lbs/yr	.....	.....	.....	.....	Foster Wheeler	Foster Wheeler
B.P. Benzin und Petroleum	Dinslaken	Cat Cracker	10,000 bbls	.....	Under Constr	1961	.....	Kellogg	Kellogg
		Copper Chloride	4.000 bbls	.....	Under Constr	1961	.....	Kellogg	Kellogg
		Bitumen	100,000 tons/yr	.....	Under Constr	1961	.....	Kellogg	Kellogg
		Prefractionation	60,000 tons/yr	.....	Engineering	July 1962	Badger	Lurgi	Lurgi
British Petroleum California Chemical	Dinslaken	Paraxylene	14,000 tons	.....	Engineering	Mid 1962	Cal Research	Staff/Lurgi	Lurgi
Caltex	Frankfurt	*Refinery	40,000 bbls	$55,000,000	Engineering	Jan 1964	.....	.....	.....
		*Ethylene	77,175 tons/yr	.....	.....	.....	.....	.....	.....
Chemische Fabrik Holten	Ludwigshaven/ Rhein	Ethylene Oxide	9,000,000 lbs/yr	.....	Under Constr	.....	SD	SD	.....
Chemische Werke Huls	Marl	Polybutadiene	20,000 tons/yr	.....	Planning	1963	.....	Staff	.....
		Exp. Polyvinylchloride	to 80,000 tons/yr	.....	Under Constr	1961	.....	Staff	.....
		Exp. Polystyrene	to 30,000 tons/yr	.....	Under Constr	1961	.....	Staff	.....
		Polypropylene	3,000 tons/yr	.....	Under Constr	End 1961	Ziegler	Staff	.....
Deutsche Erdoel	Heide	Exp. Refinery	50,000 bbls	.....	Engineering	1962	.....	Edeleanu/Staff	.....
		Urea Dewaxing	700 bbls	.....	Under Constr	1961	Edeleanu	Edeleanu	Edeleanu
		Isobutylene Extraction	770 bbls	.....	Under Constr	1961	Esso	Edeleanu	Edeleanu
		*Platforming	9,500 bbls	.....	Engineering	Summer 1962	UOP	Edeleanu	Edeleanu
		*Distillation	30,000 bbls	$4,000,000	Under Constr	Summer 1962	.....	Procon	Procon/Edeleanu
Deutsche Shell	Godorf	Exp. Platformer, Hydrodesulfurization	40,000 bbls	.....	Planning	1961	.....	.....	.....
Eblingen Gasworks	Eblingen	Cat Reformer	2.6 MMcf	.....	Under Constr	1961	Otto	Otto	Otto
		Gas Conversion	2.6 MMcf	.....	Under Constr	1961	Otto	Otto	Otto
Einbeck Gasworks	Einbeck	Cat Reformer	500 Mcf	.....	Engineering	1961	Otto	Otto	Otto
Elmshorn Gasworks	Elmshorn	Cat Reformer	750 Mcf	.....	Engineering	1961	Otto	Otto	Otto
Erdolchemie	Dormagen/ Niederrhein	Di-isobutylene, Tri-isobutylene	45,000 tons/yr	.....	Under Constr	1961	Farbenfabriken	Lurgi	Lurgi
Esso A.G.	Cologne	Steam Cracker, Ethylene Recovery, Petrochemicals	5,000 bbls	$11,000,000	Under Constr	1961	Esso	Lurgi	.....

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Esso A.G. (Cont.)	Karlsruhe	Refinery	80,000 bbls	$35,000,000	Engineering	Late 1962	Esso/ UOP	Lurgi/Lummus/ Uhde	Lurgi/Lummus/ Uhde
Ewald-Kohle	Recklinghausen	Maleic Anhydride	.....	.....	Under Constr	Late 1961	SD	SD/SFST	.....
Farbwerke Hoechst A. G.	Frankfurt-Hoechst	Propane-Propylene Splitter	1,500 tons/ month	.....	Under Constr	1961	.....	Uhde	Uhde
Feldmuhle A. G.	Lulsdorf	Acetylene	24 tons	.....	Engineering	1961	Knapsack-Grie-sheim	Uhde	Uhde
Gelsenberg Benzin A.G.	Gelsenkirchen	Platformer	12,500 bbls	$5,300,000	Under Constr	1961	UOP	Lurgi	Lurgi
		Benzene Extraction	700 bbls	$3,000,000	Under Constr	1961	UOP	Lurgi	Lurgi
Gewerkschaft Erdol-Raffinerie Emsland	Lingen Holt-hausen	Gas Oil Desulfurizer	5,500 bbls	.....	Planning	.....	UOP/ Shell	Lummus	Lummus
		Crude Distillation and Coking	10,000 bbls	.....	Planning	.....	.....	Lummus	.....
Gewerkschaft Victor Chemische Werke	Castrop-Rauxel	Synthesis Gas	22 MMcf	.....	Under Constr	Late 1961	Shell/ Lurgi	Lurgi	Lurgi
Heilbronn Gasworks	Heilbronn	Cat Reformer	5.5 MMcf	.....	Engineering	1961	Otto	Otto	Otto
Kali Chemie	Bad Henningen	Hydrogen	.....	.....	.....	.....	Hercules	Power-Gas	Power-Gas
Oberrheinische Mineralolwerke	Karlsruhe	*Sulfur	18 tons	.....	Engineering	Dec 1962	.....	Lurgi	Lurgi
		*Refinery	2,000,000 ton/yr	.....	Engineering	Dec 1963	.....	Edeleanu	Edeleanu
		*Gas Recovery	19,305 tons/yr	.....	Engineering	Dec 1962	.....	Lurgi	Lurgi
		*DEA Treating	650 bbls	.....	Engineering	Dec 1962	.....	Lurgi	Lurgi
Oelwerke Julius Schindler	Hamburg-Neuhof	Solvent Dewaxing	2,500 bbls	$4,000,000	Complete	.....	Edeleanu	Edeleanu	Edeleanu
Oleonaphtha	Brunsbuttelkoog	*Alkyl Phenols	10,000 tons/yr	$1,425,000	Under Constr	1961	Reichhold	Edeleanu	Edeleanu
		*Resins	6,000 tons/yr	$700,000	Under Constr	Early 1962	Reichhold	Edeleanu	Edeleanu
		Refinery Modernization	.....	.....	Engineering	1962	.....	Uhde	Uhde
Polycarbona Chemie	Moers-Meerbeck	*Maleic Anhydride	6,000 tons/yr	.....	Planning	Early 1962	S D	S D	S D/Edeleanu
Purfina	Duisberg	*Exp. Crude	to 1,500,000	.....	Under Constr	End 1961	.....	Lummus/Staff	Lummus
Mineraloelraffinerie		*Exp. Platformer, Unifiner	6,000 bbls	.....	Under Constr	Spring 1962	.....	Lummus/Staff	Lummus
Rheinpreussen A. G.	Meerbeck	Maleic Anhydride	.....	.....	Engineering	Spring 1962	SD	SD/SFST	.....
Ruhrchemie	Oberhausen-Holten	Polyethylene	.....	.....	Under Constr	.....	Staff	Uhde	Staff/Uhde
		*Nitric Acid	60 tons	.....	Under Constr	Mid 1963	Uhde	Uhde	Uhde
Scholven Chemie A. G.	Gelsenkirchen-Buer	Ethylene	.....	.....	Planning	.....	.....	Lummus	Lummus
Union Rheinische Braunkohlen Kraftstoff A. G.	Wesseling	Synthesis Gas	10 MMcf	.....	Under Constr	1961	Shell/	Lurgi	Lurgi
	.....	Synthesis Gas	10 MMcf	.....	Under Constr	Early 1962	Shell/ Lurgi	Lurgi	Lurgi
		*Crude Distillation	.....	.....	Under Constr	1961	.....	Uhde	Uhde
Westdeutsche Erdolleitungs-Gesellschaft	Ruhlermoor	Crude Distillation	.....	.....	Under Constr	1961	.....	Uhde	Uhde
		Crude Desalter	5,700 bbls	.....	Complete	.....	Howe-Baker	Uhde	Uhde
Wintershall A.G.	Dueste	Gas Purification	28 MMcf	$2,000,000	Engineering	Fall 1962	Fluor	Fluor	Fluor
GREECE									
Dow Chemical	Lavrion	Polystyrene Plastic	.....	$1,000,000	Under Constr	1961	.....	Foster Wheeler	Foster Wheeler
Greek Government	Ptolemaeus	Ammonia	300 tons	.....	Under Constr	Mid 1963	Uhde, Casale	Uhde ERI	Uhde, Casale
		Ammonium Sulfate	525 tons						
		Ammonium Nitrate	325 tons						
Hellenic Petroleum Refinery	Aspropygas	LPG	25,000 tons/yr	.....	Under Constr	Late 1961	.....	Hydrocarbon	Staff
HUNGARY									
Komplex	Borento	PVC Suspension	.....	.....	Planning	.....	Hoechst	Uhde	Uhde
ITALY									
Asfalti Bitumi Cementic Derivati, S.A.	Ragusa	Exp. Polyethylene	to 80 tons	.....	Under Constr	.....	.....	.....	.....
Azienda Nazionale Idrogenazione Combustibil	Ravenna	Butadiene	22,000 tons/yr	.....	Engineering	.....	Houdry	Catalytic	.....
		Ethylene	.....	.....	Under Constr	.....	Koppers	ANIC	.....
	Gela, Sicily	Refinery	.....	.....	Under Constr	1962	.....	.....	.....
		Ethylene	.....	.....	.....	.....	.....	S & W	.....
Bombrini Parodi-Delfino	Colleferro	Maleic Anhydride	10,000,000 lbs/yr	.....	Engineering	Mid 1962	SD	SD	.....
Condor Societa per L'Industria Petro-lifera e Chemica	Rho	Crude Distillation Revamp	6,000 bbls	.....	Under Constr	Early 1962	.....	Staff	.....
		*Aromatics Extraction	270 tons	.....	Under Constr	End 1961	Shell	BIPM/CTIP	.....
		*Asphalt Blowing	300 tons	.....	Under Constr	Mid 1962	.....	BIPM/CTIP	.....
Dow Chemical Italiana	Livorno	Polystyrene	.....	.....	Under Constr	1962	.....	Foster Wheeler	Foster Wheeler
Industria Raffinazione Oil Minerali	Venice	Cat Reformer	4,000 bbls	.....	Under Constr	1961	UOP	UOP/SNAM Progetti	SNAM Progetti
		Unifiner-Platformer	4,000 bbls	.....	Under Constr	1961	UOP	UOP/SNAM Progetti	SNAM Progetti
Mobil Chimica Italiana	Naples	*Aromatics	165,375 tons/yr	$15,000,000	Engineering	Early 1963	UOP/ Cosden/ Amoco/ Engel-hard	CTIP	CTIP
Montecatini Societe Generale per l'Industria Mineraria Chimica	Ferrara	Exp. Polypropylene	2,200,000 lbs/yr	.....	Under Constr	.....	SD	SD	.....
	Castellanza	Exp. Formaldehyde	.....	.....	Planning	.....	.....	.....	.....
	Brindisi	Petrochemical	135,000,000 lbs/yr	$300,000	Under Constr	.....	.....	.....	.....
			700,000 tons/yr	$95,000,000	Under Constr	1962	.....	.....	.....
Phillipe Petroleum & ANIC	.....	Carbon Black	25,000,000 lbs/yr	.....	Planning	1962	Phillips	.....	.....
Purfina Italiana	Rome	Refinery	33,000 bbls	$16,000,000	Planning	1963	.....	.....	.....
	Genoa	Topping Revamp	13,000 bbls	$500,000	Complete	.....	.....	Staff	Staff
		Trickle Hydrodesulfurization	2,200 bbls	$350,000	Engineering	1962	Shell	CTIP	Staff
Sincat	Priolio, Sicily	Ethylene	2,200 bbls	$500,000	Engineering	1961	Shell	CTIP	Staff
Societa per l'Industria Italiana del Petrolio	La Spezia	*Crude Distillation	80,000 bbls	.....	Planning	1964	.....	.....	.....
Societe per Azonial Reffineria Olii Minerali	Ravenna	Cat Reformer	.....	.....	.....	.....	.....	Foster Wheeler	.....
Union Carbide Societa Edison S.A.	Sicily	Polyethylene	.....	.....	.....	.....	.....	.....	.....
	Celene	Ethylene Oxide	15,000 tons/yr	.....	Complete	.....	.....	.....	.....
	Mantua	Acetaldehyde	.....	.....	Planning	.....	Aldehyd	Uhde	Uhde
NETHERLANDS									
Elektro-Zuur en Waterstoffabriek	Amsterdam	Acetylene	32 tons	.....	Engineering	1961	Knapsack-Grie-sheim	Uhde	Uhde
N.V. Chemische Industries Synres, Allied Chemical	Hoek van Holland	Phthalic Anhydride	10,000,000 lbs/yr	.....	Engineering	1962	Sherwin-Williams	Badger NV	Badger NV
N.V. Mattschappij Tot Exploitatie Van Kooksoven-gossen	Ijmuiden	Gas Reforming	4.4 MMcf	.....	Under Constr	.....	.....	.....	.....
		CO Conversion	.....	.....	Planning	.....	.....	.....	.....
Shell Nederland Raffinaderij N.V.	Pernis	Platformer	6,700 bbls	.....	Under Constr	End 1961	.....	.....	.....
		Hydrodesulfurization	15,000 bbls	.....	Under Constr	End 1961	.....	.....	.....
		*Synthetic Organic Acids	.....	$5,600,000	Under Constr	Early 1962	Shell	.....	.....

*First appearance in tabulation.

21 Procon-built plants meet benzene demand

The growth of the plastics and synthetic fiber industries has created an increasing world demand for benzene. To help meet this requirement Procon has built or is completing 21 plants . . . in every section of the United States . . . as well as other free world locations such as Germany, Brazil, Canada, The Canary Islands and Australia.

■ Typical of Procon's petrochemical construction, these benzene plants provide adaptability and versatility through the incorporation of the Udex and/or Hydeal processes. Udex permits the recovery of high-purity benzene and other aromatics from petroleum hydrocarbon mixtures . . . while Hydeal allows production of benzene from toluene and xylenes for greater economic flexibility.

■ If you require construction in the chemical, petrochemical or petroleum refining industries . . . no matter what the process, the product or the location . . . Procon can do the job . . . complete it on or before the agreed date . . . to your satisfaction.

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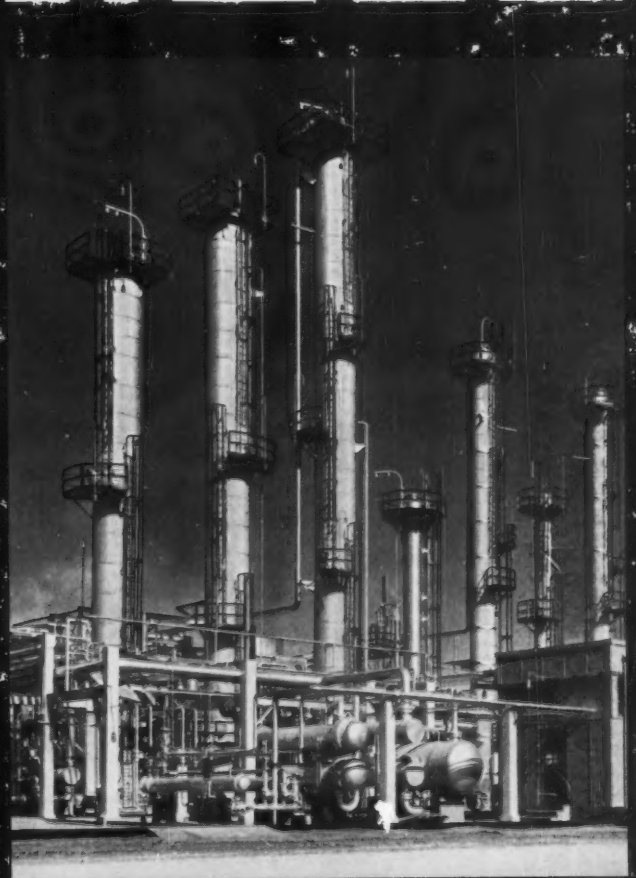

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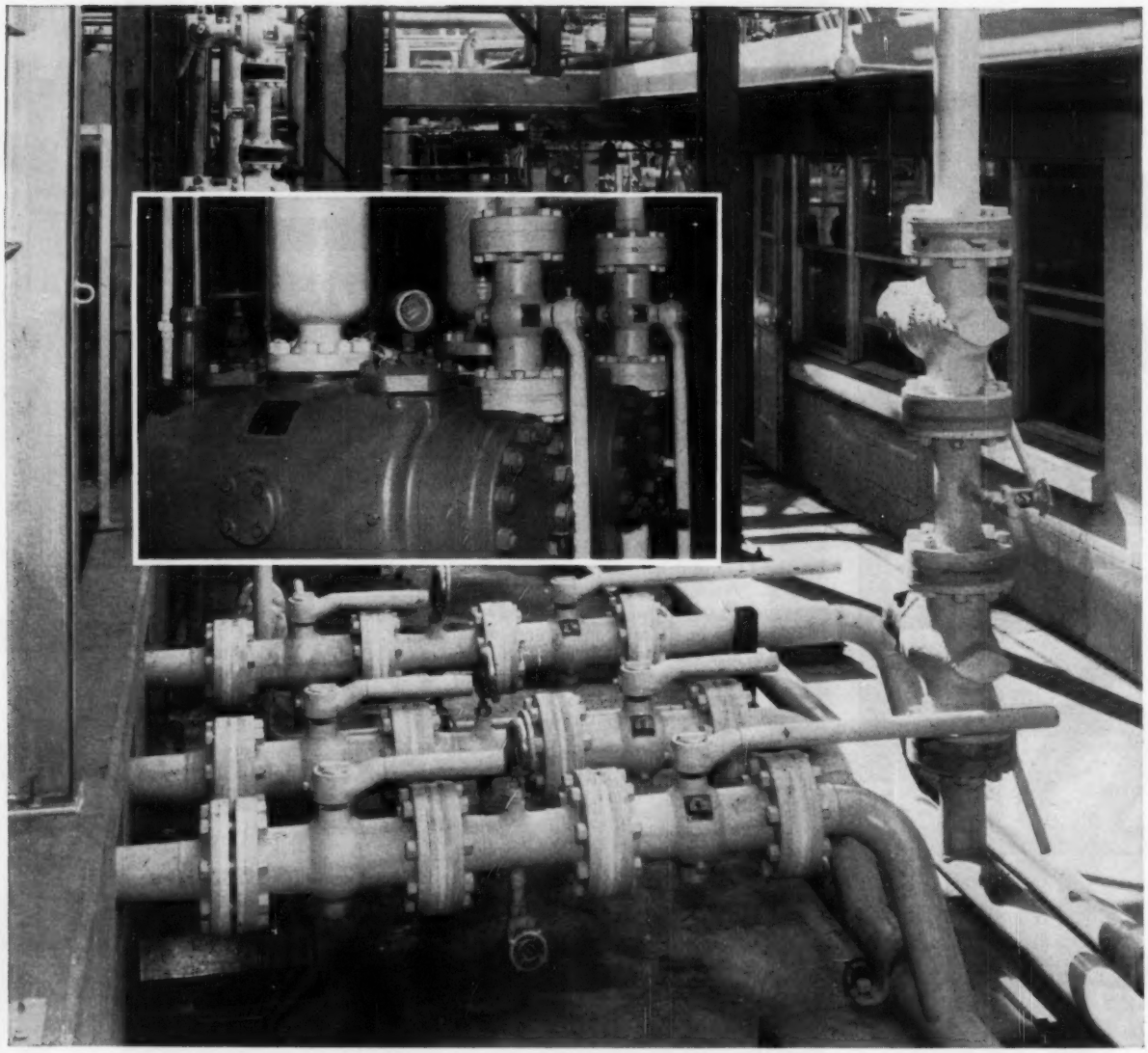

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Cameron Ball Valves can be made of materials best suited to your needs, whether your problem is the handling of acids, alkalies or abrasives. Cameron's unique method of fabrication permits the use of exotic materials.

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CAMERON IRON WORKS, INC.
P. O. BOX 1212 HOUSTON, TEXAS

HPI CONSTRUCTION BOXSCORE—*Continued*

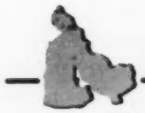
COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Staatsmijner in Limburg	Geleen	Phthalic Anhydride	.....	.....	Under Constr	1961	SD	SFST	.....
		Ethylene	.....	.....	.....	.....	.....	S & W	S & W
Tilburg Gasworks....	Tilburg	Cat Reformer	6.8 MMcf	.....	Engineering	1961	Otto	Otto	Otto/Simon-Carves
NORTHERN IRELAND									
British Petroleum	Belfast	Refinery	30,000 bbls	$22,400,000	Planning	.....	.....	.....	.....
POLAND									
Polish Government...	Plock	Refinery	40,000 bbls	.....	Planning	1965	.....	.....	.....
		Hydrogen	1.5 MMcf	.....	.....	.....	.....	.....	.....
		Fuel Gas	11 MMcf	.....	.....	.....	.....	.....	.....
PORTUGAL									
Petroquimica S.a.r.L..	Lisbon	Ammonia	187 tons	.....	Under Constr	1961	Texaco/ Uhde	Uhde/STEC	Uhde/STEC
Sociedade.....	Lisbon	CO Boiler	720 tons	$360,000	Engineering	Dec 1961	.....	John Thompson	John Thompson
Anonima		Topping Revamp	5,000 tons	$350,000	Engineering	Jan 1962	.....	Litwin	Staff
Concessionaria da Refinacao de Petroleos		Fractionation	460 tons	$600,000	Engineering	Feb 1962	.....	Hydrocarbon	Hydrocarbon
		TCC Revamp	2,300 tons	$650,000	Engineering	Early 1962	Socony Mobil	Hydrocarbon	Staff
União Fabril do Azoto.	Lavradio, near Lisbon	Urea	135 tons	.....	Under Constr	1962	.....	Kellogg	Kellogg
		*Ammonia	198 tons	.....	Under Constr	1962	.....	Kellogg	Kellogg
		*Nitric Acid	.....	.....	Under Constr	1962	.....	.....	Kellogg
		*Ammonium Nitrate	.....	.....	Under Constr	1962	.....	.....	Kellogg
RUMANIA									
Rumanian Govt.....	Teleajen	Lube Oil	.....	.....	Planning	.....	.....	.....	.....
		Natural Gas Treating	.....	.....	Planning	.....	.....	.....	.....
	Borzesti	Petrochemical	.....	.....	Planning	.....	.....	.....	.....
		Polystyrene	.....	.....	Under Constr	.....	Petro-carbon	Petrocarbon	Petrocarbon/ Staff
	Onesti	Synthetic Rubber	.....	.....	Planning	.....	.....	.....	.....
SCOTLAND									
British Hydrocarbon Chemicals	Grangemouth	Methanol	.....	.....	Complete	.....	.....	Chemico	Chemico
Scottish Gas Board...	Fifeshire	Stage 2 Pressure Gasification	15 MMcf	.....	Under Constr	Mid 1962	Lurgi et al	H & G	H & G
	Edinburgh	*Refinery Gas Reforming	19 MMcf	.....	Engineering	Late 1962	Onia Gegi	H & G	H & G
SPAIN									
Abonos Sevilla.....	Sevilla	*Fertilizers	111 tons/yr	.....	Under Constr	Mid 1962	.....	Lummus	Lummus
Monsanto Iverica S.A.	Monzen	Acetaldehyde, Acetic Acid	.....	.....	Planning	.....	Knapsack-Griesheim	Uhde	Uhde
Repesa.....	Escombreras (Cartagena)	Ammonia	325,000,000 lbs					Foster Wheeler	Foster Wheeler
		Ammonium Sulfate	600,000 tons	$32,000,000	Under Constr	1962	Texaco/ Giamma-rco/ DSM	Uhde	Uhde
		Urea	210,000 tons					Chemico/Dorr-Oliver	Chemico/Dorr-Oliver
		Urea	.....	.....	Engineering	.....		Braun	Foster Wheeler
SWEDEN									
Mo och Domsjo Aktiebolag	Stenungsund	Ethylene Oxide	33,000,000 lbs/yr	.....	Engineering	Mid 1962	SD	SD	.....
Svenska Esso A.B....	Stenungsund	Steam Cracking	.....	$15,000,000	Engineering	Spring 1963	.....	Fluor	Fluor
SWITZERLAND									
Miranco.....	Mendrisio	Lube Oils	500 bbls	$1,500,000	Under Constr	.....	.....	Staff	.....
U.S.S.R.									
Techmachimport.....	Angarsk, Siberia	Acetylene	.....	.....	Engineering	.....	SBA	SBA	SBA
		Synthetic Ammonia	.....	.....	Engineering	.....	SBA	SBA	ERI
		Polystyrene	5,000 tons/yr	.....	Engineering	1962	BX Plastics	Power-Gas	Power-Gas
WALES									
British Hydrocarbon Chemicals	Baglan Bay, South Wales	Petroleum Chemicals	.....	.....	Planning	.....	.....	.....	.....
		Ethylene	.....	.....	Under Constr	1962	.....	S & W	S & W
		Ethylene Dichloride	.....	.....	Under Constr	1962	Ethyl	Lummus	Lummus
		Butadiene	.....	.....	Under Constr	1962	Shell	S & W	S & W
Forth Chemicals.....	Baglan Bay, South Wales	Styrene Monomer	50,000 tons/yr	$14,400,000	Under Constr	1962	Monsanto	Monsanto	.....
YUGOSLAVIA									
Komplex.....	Berente	Acetylene	12 tons	.....	Engineering	1962	Hoechst	Uhde	Uhde
Proizvodnja Nafte....	.....	*Synthesis Gas	.....	.....	Engineering	.....	SBA/ TOPSOE	SBA	.....
Yugoslav Govt.....	Sisak	Topping	15,000 bbls						
		Delayed Coking	4,950 bbls	$10,000,000	Planning	Spring 1963	.....	.....	.....
		Platforming	3,020 bbls						
	Kutina	Ammonia	.....	.....	Planning	.....	.....	.....	.....
	Zagreb	Petrochemicals	.....	.....	Planning	Mid 1962	.....	Foster Wheeler	Foster Wheeler
	Rijeka	Topping	1,000,000 tons/yr	.....	Planning	.....	.....	.....	.....
		Naphtha Rerunning	140,000 tons/yr						
		Platforming	100,000 tons/yr						
		Sulfur Recovery	5,000 tons/yr	.....	.....	.....	.....	.....	.....
	Bosanski Brod	Topping	640,000 tons/yr	.....	Planning	.....	.....	.....	.....

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
ALGERIA									
Societe de La Raffinerie D'Alger	Algiers	Refinery	55,000 bbls	$40,000,000	Under Constr	July 1963	.....	.....	Compagnie Francaise de Raffinage
Societe Nationale Repal	Hassi Er R'Mel	Gas Separation & Drying	140 MMcf	$2,400,000	Under Constr	1961	.....	Technip	Staff
	Hassi Messaoud	Refinery, Storage	.....	.....	Planning	.....	.....	Lummus	Lummus
CANARY ISLANDS									
Compania Espanola de Petroleos, S.A.	Teneriffe	Crude Distillation	50,000 bbls		Under Constr	Late 1961	UOP	Procon	Procon
		Unifiner-Platformer	15,000 bbls	$6,000,000	Under Constr	Late 1961	UOP	Procon	Procon
		Boilers— Turbogenerators, Tanks			Under Constr	1962	AFG & VKW	AFG & VKW	AFG & VKW
		Merox	4,000 bbls	.....	Planning	.....	.....	.....	.....
		Kerosine, SO_2 Extraction	3,500 bbls	$1,000,000	Engineering	1962	Badger Mfg	Badger Ltd	Badger Ltd
		Vacuum Distillation	7,800 bbls	.....	Under Constr	1961	.....	Foster Wheeler	Foster Wheeler
EGYPT									
Anglo-Egyptian Oilfields	Sues	Cat Reformer	2,300 bbls	.....	Planning	.....	.....	.....	.....

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Egyptian Chem. Ind./KIMA S.A.E.	Aswan	Ammonia	415 tons	$48,000,000	Complete	.....	Uhde/ BASF	Uhde/BASF	Uhde/BASF
United Arab Republic	Alexandria	Atmospheric & Vacuum Distillation	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
	Cairo	Atmospheric & Vacuum Distillation	10,000 bbls	$1,400,000	Planning	.....	.....	.....	.....
KENYA									
British Petroleum/ Shell	Mombasa	Refinery	40,000 bbls	.....	Planning	1964	.....	.....	.....
MOROCCO									
Ente Nazionale Idrocarburi	Mohammedia	Refinery	25,000 bbls	.....	Under Constr	1962	.....	SNAM Progetti	SNAM Progetti
MOZAMBIQUE									
Sociedade Nacional de Refinacao de Petroleos	Lourenco Marques	Refinery: Crude Platformer Unifiner Merox	12,000 bbls 2,500 bbls 2,000 bbls 1,500 bbls	.....	Complete	.....	.....	Procon	Procon
NIGERIA									
British Petroleum/ Shell	Port Harcourt	Refinery	20,000 bbls	$33,600,000	.....	.....	.....	.....	.....
SOUTH AFRICA									
AE & CI.....	Modderfontien	Synthetic Ammonia	70,000 tons	.....	Under Constr	.....	.....	Staff/ICI/ Power-Gas	Power-Gas
Phillips Petroleum-Industrial Development	.....	Carbon Black	22,000,000 lbs/yr	.....	Complete	.....	Staff	Staff	Staff
S.A. Coal Oil & Gas..	.....	Hydrogen	.....	.....	Engineering	.....	Hercules	Power-Gas	.....
South African Petroleum Refineries	Durban	Refinery	62,000 bbls	$70,000,000	Planning	1964	.....	.....	.....



Middle East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
IRAN									
Iranian Govt.....	Shiraz	Nitric Acid	30,000 tons/yr	$30,000,000	Under Constr	.....	SBA	SBA/Foster Wheeler	CJB
		Ammonium Nitrate	.....	.....	Under Constr	.....	SBA	SBA/Foster Wheeler	.....
Iranian Oil Refining...	Abadan	Cat Reformer	20,000 bbls	$5,000,000	Under Constr	Spring 1962	UOP	Fluor	Fluor
IRAQ									
Iraq Petroleum.....	Kirkuk	Oil Sweetening	250,000 bbls	$1,250,000	Under Constr	Oct 1961	.....	Staff/Foster Wheeler	Foster Wheeler
		Oil Sweetening	400,000 bbls	.....	Under Constr	Jan 1962	.....	Staff/Foster Wheeler	Foster Wheeler
KUWAIT									
American Independent Oil	Mina Abdulla	*Refinery	100,000 bbls	.....	Under Constr	Jan 1962	.....	Parsons	Parsons
Kuwait Oil.....	Mina al Ahmadi	Bulk LPG	6,500 bbls	.....	Under Constr	Late 1961	.....	Wimpey-Bechtel International	Kuwait Bechtel
PAKISTAN									
Pakistan Industrial Development	Frnchanj	Ammonia	225 tons	$20,000,000	Engineering	1961	Kobe	Chemico	Chemico
		Urea	375 tons	.....	.....	.....	Steel	.....	.....
Pakistan Refinery/ Shell/Standard Vacuum Oil, et al	Korangi Karachi	Refinery: Crude Distillation Hydrotreater Platformer Crude Distillation Hydrotreater Catalytic Reformer	34,000 bbls	.....	Under Constr	Early 1963	.....	Kellogg	Kellogg International
Sui Carbon.....	.....	Carbon Black	36,000,000 lbs/yr	.....	Planning	.....	.....	.....	.....
SAUDI ARABIA									
Arabian American Oil.	Ras Tanura	Asphalts	.....	.....	Complete	.....	.....	.....	.....
		Refrigerated LPG	4,000 bbls	$7,500,000	Complete	.....	.....	Staff	Staff
		*Inline Blending	400,000 bbls	$600,000	Complete	.....	.....	Staff/B-I-F Industries	Staff
United Arab Republic	Suez	Refinery: Atmospheric & Vacuum Distillation	20,000 bbls	$3,000,000	Under Constr	1961	.....	Techno-Export	Techno-Export
		Lube Oils	4,000 bbls	$12,000,000	Engineering	1963	.....	Tiajpromexport	Tiajpromexport
		Vapor Recovery	2,500 bbls	$1,500,000	Under Constr	1962	.....	Lummus	Lummus
		Delayed Coker, Cat Reforming	20,000 bbls 9,700 bbls	$60,000,000	Under Constr	1963	UOP/ Engelhard	Braun	CTIP
Arabian Oil of Japan..	Kuwait	Topping & Utilities	20,000 bbls	.....	Planning	1962	.....	.....	.....
		Refinery	50,000 bbls	.....	Planning	1965	.....	.....	.....
TURKEY									
Istanbul Petrol Rafinieri Anonim Sirketi (IPRAS)	Izmit	Refinery: Crude Distillation Naphtha Unifiner Platformer Distillate Hydrotreater Catalytic Cracker	20,800 bbls	$26,000,000	Under Constr	End 1961	.....	Kellogg	Kellogg
Anadolu Tasfiyehanesi A.S. (ATAS)	Mersin	Refinery: Crude Distillation, Naphtha Pretreating, Naphtha Catalytic Reforming, Kerosine Catalytic Hydrodesulfurization	65,000 bbls	$48,000,000	Under Constr	End 1961	.....	Foster Wheeler	Foster Wheeler

Far East

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
FORMOSA									
Chinese Petroleum...	Kaohsiung	Catforming	5,000 bbls	.....	Engineering	April 1962	Engelhard	Fluor/Staff	Staff
Pioneer Chemical.....	Taipei	Coal Tar Distillation	36 tons	.....	Under Constr	Dec 1961	.....	Ishii Iron Works	.....
INDIA									
Fertilizers & Chemicals Travancore	Alwaye, Kerala State	Partial Oxidation Gasification	.....	.....	Engineering	June 1962	Texaco	Power-Gas	Power-Gas
		Carbon Monoxide Pressure Conversion	.....	.....	Engineering	.....	Power-Gas	Power-Gas	Power-Gas

*First appearance in tabulation.

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Popular thinking on any subject is often like a pendulum, swinging forward in sheer exhilaration over an exciting idea, then backward to a cynical attitude against it. Years ago, health columnists extolled the nutritive qualities of spinach. Shortly thereafter, it was equally popular to decry spinach as an overglamorized weed.

This vacillation springs from the efforts of spokesmen to capture interest, and the tendency of many people, like wild creatures in the forest, to give attention to whatever is moving regardless of the direction. That is why it sometimes seems that the more preposterous an idea the more credence it receives.

World War II, with its demands for hundreds of thousands of leaders to be developed quickly, accelerated the concept of training men in human relations. Many veterans tried, after the war, to apply the principles to industry. Supervisor and management development became extremely popular. Some of these programs naturally fell short of expectations, and there are always detractors — ready to display their intellectual brilliance by speaking cynically of *all* types of human relations training. Real progress in supervisory methods has, therefore, been slow.

Supervisory personnel, continually aware of the intrinsic values of human relations, are the key to uninterrupted production, completion of projects successfully and on time, for they forge the links in the productive chain solidly together.

Your management is interested not only in the creative, bold steps you would take into unknown solutions to problems, but also in how quickly and productively (profitably) you can put these ideas into practical application. When the solution, or idea, leaves your desk and starts down the long line of being put into practice, supervisors throughout that chain of action and their relationships with those about them — will determine to a great extent whether their individual components will function properly or whether a project will bog down under the weight of misunderstanding and apathy.

It signals to the engineer in charge, therefore, the importance of maintaining good supervisory practices throughout the various departments through which the original concept must be translated. It means a thorough understanding of human relations yourself, and the ability to communicate this understanding and appreciation to the supervisory personnel under you. This can and probably must be done both by individual contact with your supervisors and/or by conducting actual courses of study on the subject.

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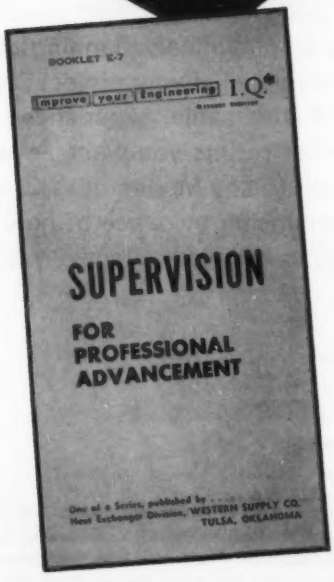
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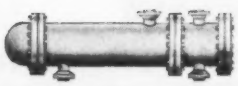
. . . the foregoing paragraphs are a direct quotation from another of Western's personal-professional-development series, copies of which are available upon request at no charge. Western's conviction about the importance of competent supervisors as an adjunct to efficient engineering work is founded upon direct observation in our own plant, where trained supervisors contribute greatly to the manufacture of heat exchangers of the highest quality, and where personal attention to detail is their watchword. We invite your inquiry when heat transfer problems arise.



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INTERNATIONAL ENGINEERING AND CONSTRUCTION SERVICES

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Fertilizers & Chemicals Travancore (Cont.)	Alwaye, Kerala State (Cont.)	Carbon Dioxide & Hydrogen Sulfide Removal	.....	.....	Engineering	.....	Power-Gas	Power-Gas	Power-Gas
Fertilizer Corp. of India	Barauni	Refinery	40,000 bbls	.....	Planning	1962	.....	USSR Govt	USSR Govt
	Nahorkatiya, Assam	Ammonium Sulfate	155 tons	.....	Under Constr	June 1964	Indian Govt	.....	.....
		Urea	155 tons						
Firestone Tire & Rubber	Bareilly	Synthetic Rubber	20,000 tons/yr	$30,000,000	Under Constr	1962	.....	Lummus	Lummus
		*Butadiene	23,000 tons/yr		Engineering	.....		Lummus	Lummus
		Styrene	9,000 tons	.....	Engineering	Late 1962	Chemische Werke Huls	Firma Carl Still	Lummus
Hindustan Chemical & Fertilizers	Trombay	*Ammonia, Urea, Nitric Acid	.....	$21,000,000	Engineering	Late 1962	Chemico	Chemico	.....
Hindustan Steel	Rourkela	Ammonia	514 tons	.....	Under Constr	1961	Uhde	Uhde	Uhde
India Carbon	Gauhati (Assam)	*Calcined Petroleum Coke, Anthracite	.....	.....	Planning	.....	.....	Great Lakes Carbon	.....
Indian Refineries	Nunmati	*Refinery	750,000 tons/yr	$40,000,000	Under Constr	End 1961	Indian Govt	Rumanian Govt	Rumanian Govt
	Barauni (Bihar)	*Refinery	20,000 000 tons/yr	$85,000,000	Under Constr	1963	Indian Govt	Russian Govt	Russian Govt
	Gujerat	*Refinery	2,000,000 tons/yr	.....	Planning	1964	Indian Govt	.....	.....
Neyveli Lignite	Neyveli	Urea	500 tons	$52,500,000	Engineering	Early 1963	.....	Montecatini/ Pintschbamag	Montecatini/ Pintschbamag
Oil India Private	Nunmati (Assam)	Refinery	750,000 tons/yr	$10,500,000	Under Constr	1961	Indian Govt	Rumanian Govt	Rumanian Govt
Phillips Carbon Black	Durgapur	Carbon Black	30,000,000 lbs/yr	.....	Under Constr	June 1962	Phillips Petroleum	Phillips Petroleum/Snam Progetti	Snam Progetti
Sahu Chemicals	Varanasi	Ammonia	120 tons	.....	Under Constr	.....	John Thompson	CECIP	John Thompson
	Sahupuri	Ammonia	40 tons	.....	Engineering	.....	.....	.....	.....
JAPAN									
Asahi Glass	Osaka	Propylene Oxide	320 tons/month	.....	Complete	.....	Staff	JGC	JGC
		Propylene Glycol	200 tons/month	.....	Complete	.....	Staff	JGC	JGC
Asia Oil	Yokohama	Unifiner	3,000 bbls	$1,000,000	Engineering	1961	UOP	UOP/JGC	JGC
		Unifiner-Platformer	5,000 bbls	$3,770,000	Engineering	1961	UOP	UOP/JGC	JGC
		Merox	4,000 bbls	$119,000	Engineering	1961	UOP	UOP/JGC	JGC
		Topping Desalter	30,000 bbls	$1,980,000	Engineering	1961	.....	Chiyoda	Chiyoda
		Gas Concentration	1.6 MMcf	$511,000	Engineering	1961	.....	UOP/JGC	JGC
Chubu Gas	Chubu	Catalytic Oil Gasification	1 MMcf	.....	Under Constr	Dec 1961	Onia Gegi	H & G	Ishii Iron
Daikyo Oil	Yokkaichi	Furfural	1,500 bbls	$835,000	Under Constr	July 1962	Texaco	Texaco/ Chiyoda	Chiyoda
Dai Nippon Chemical	Ikuna	*Topping-Vacuum	50,000 bbls	.....	Engineering	Oct 1962	.....	JGC	JGC
		Butanol	.....	.....	Planning	.....	Hoechst	Uhde	Uhde
	Otake	Butanol	1,000 tons/ month	.....	Under Constr	Feb 1962	Hoechst	Uhde/JGC	JGC
		Crotonaldehyde	1,730 tons/ month	.....	Under Constr	Feb 1962	Hoechst	Uhde/JGC	JGC
		Methoxybutanol	140 tons/month	.....	Under Constr	Feb 1962	Hoechst	Uhde/JGC	JGC
Denki Kagaku	Tsumi	*Chloroprene	16 tons	.....	Under Constr	April 1962	.....	Staff/Chiyoda	Staff/Chiyoda
	Ohmi	*Polyvinyl Alcohol	22 tons	.....	Under Constr	Oct 1962	.....	Staff/Chiyoda	Staff/Chiyoda
Furukawa Chemical Industries	Japan	Platforming	5,000 bbls	.....	Planning	.....	UOP	UOP/JGC	.....
Fuji Iron & Steel	Himeji	Unifining, Udex	700 bbls	.....	Complete	.....	UOP	UOP/JGC	JGC
		*Hydrar	36 tons	.....	Planning	Oct 1962	UOP	UOP/JGC	JGC
		*Unifiner-Hydeal	700 bbls	.....	Under Constr	Oct 1962	UOP	UOP/JGC	JGC
	Muroran	Merox	5,700 bbls	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
General Oil	Kawasaki	Unifiner-Platformer	6,000 bbls	.....	Under Constr	.....	UOP	UOP/JGC	JGC
General Sekiyu	Kawasaki	Unifiner-Platformer	9,000 bbls	$6,517,000	Engineering	Mid 1962	UOP	UOP/JGC	JGC
Idemitsu Kosan	Chiba	Desalter	100,000 bbls	$150,000	Engineering	Sept 1962	Petreco	Petreco/ Chiyoda	Fujinagata/ Chiyoda
		Gas Conditioning	.....	.....	Planning	.....	UOP	JGC	JGC
		*Topping	100,000 bbls	$5,650,000	Engineering	Mid 1962	.....	Fujinagata	Fujinagata
		Unifiner	10,000 bbls	$2,094,000	Engineering	Mid 1962	UOP	UOP/JGC	JGC
		Merox	5,000 bbls	$325,000	Engineering	Mid 1962	UOP	UOP/JGC	JGC
		*Gas Concentration	300 tons	$1,000,000	Engineering	Mid 1962	.....	JGC	JGC
		CO_2 Removal	374 Mcf	$30,000	Planning	.....	.....	Tears	Iino-Tears
Japan Petrochemical	Tokyo	Exp. Synthetic Butadiene	5,000 tons/yr	.....	Engineering	Dec 1961	Goodyear	JGC	JGC
Japan Synthetic Rubber	Yokkaichi	Rubber	.....	.....	.....	.....	.....	.....	.....
		Exp. Butadiene	5,000 tons/yr	.....	Engineering	Oct 1961	Esso	JGC	JGC
		Butyl Rubber	5,000 tons/yr	.....	Planning	March 1962	Esso	.....	.....
		Iso-Butylene	30,000 tons/yr	.....	Planning	Dec 1962	.....	.....	.....
		cis-Polybutadiene	.....	.....	Planning	.....	.....	.....	.....
		Carbon Black Masterbatch	10,000 tons/yr	.....	.....	.....	Columbia	.....	.....
		*Butane-Butylene Recovery	10,000 tons/yr	.....	Planning	May 1962	.....	.....	.....
		*Feed Preparation	150,000 tons/yr	.....	Planning	Sept 1962	.....	.....	.....
Karonite Chemical	Kawasaki	Lube Oil Additives	2,000,000 gals/yr	.....	Engineering	Mid 1962	Cal Chemical	.....	.....
Koa Oil	Iwakuni	Merox	.....	.....	Planning	.....	UOP	UOP/JGC	JGC
		Unifining	10,000 bbls	$2,500,000	Engineering	June 1962	UOP	UOP/JGC	JGC
		Udex	2,500 bbls	.....	Planning	Late 1962	UOP	UOP/JGC	JGC
	Marifu	Unifiner	10,000 bbls	$2,200,000	Engineering	June 1962	UOP	UOP/JGC	JGC
		Udex	2,500 bbls	$2,800,000	Planning	.....	UOP	UOP/JGC	JGC
		*Exp. Fluid Cat Cracking	to 11,000 bbls	$450,000	Under Constr	Nov 1961	UOP	UOP/JGC	JGC
		*Exp. Coker	to 7,500 bbls	$610,000	Engineering	July 1962	.....	.....	.....
		*Reformer	6,500 bbls	$5,500,000	Planning	Late 1963	.....	.....	.....
Kokan Chemical Industries	Kawasaki	Ethylbenzene	21,000 tons/yr	.....	Engineering	Oct 1961	UOP	UOP/JGC	JGC
		Styrene Monomer	19,000 tons/yr	.....	Under Constr	Dec 1961	UOP	UOP/JGC	JGC
		Unifiner	450 bbls	.....	Engineering	July 1962	UOP	UOP/JGC	JGC
Kureha Chemical	Nakoso City	Perchloroethylene	.....	.....	Under Constr	.....	SD	SD	.....
Kyowa Gas	Nigatta	Acetylene	60 tons	.....	Engineering	Early 1962	BASF	Chemico	Staff
		Methanol	220 tons	.....	Engineering	Early 1962	Chemico	Chemico	Staff
Kyowa Hakko Kogyo		Acetaldehyde	.....	.....	Planning	.....	Aldehyde	Uhde	Uhde
Maruzen Oil	Goi	Atmospheric & Vacuum Crude Distillation	100,000 bbls	.....	Under Constr	March 1962	.....	Texaco/ Chiyoda	Chiyoda
	Chiba	Desalter	100,000 bbls	.....	Engineering	Sept 1962	.....	Howe-Baker	.....
		Topping	100,000 bbls	.....	Engineering	Sept 1962	.....	Staff	.....
		Unifiner-Platformer	10,000 bbls	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
		Unifiner	5,000 bbls	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
		Merox	2,500 bbls	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
		Gas Recovery	4,500 bbls	.....	Engineering	Sept 1962	.....	Staff	.....
	Kanto	*Unifiner-Platformer	10,000 bbls	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
		*Unifiner	5,000 bbls	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
		*Gas Concentration	.....	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
		*Merox	2,500 bbls	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
Miike Gosei Chemical	Omuta City, Kyushu	Maleic Anhydride	8,000,000 lbs/yr	.....	Under Constr	.....	SD	SD	.....
Mitsubishi Oil	Mizushima	Unifiner-Platformer	3,600 bbls	$3,040,000	Under Constr	1961	UOP	Chiyoda/ JGC/UOP	Chiyoda

*First appearance in tabulation.

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Mitsubishi (Cont.)		Unifiner	7,200 bbls	$2,200,000	Under Constr	1961	UOP	Chiyoda/ JGC/UOP	Chiyoda
		Unifiner	4,200 bbls	$1,260,000	Planning	Feb 1962	UOP	Chiyoda/ JGC/UOP	Chiyoda
		*Unifiner-Platformer	4,000 bbls	.....	Under Constr	Oct 1961	UOP	UOP/JGC	JGC
		*Unifiner	8,000 bbls	.....	Under Constr	Oct 1961	UOP	UOP/JGC	JGC
		Hydrogen	5,900,000 scf	$1,480,000	Planning	March 1963	.....	Chiyoda	Chiyoda
		Cat Cracking	7,600 bbls	$2,710,000	Planning	Feb 1963	.....	Chiyoda	Chiyoda
		Fluid Coker	5,600 bbls	$3,720,000	Planning	March 1963	Esso	Chiyoda/Esso	Chiyoda
		Gas Recovery	801,000 bbls	$2,300,000	Planning	Feb 1963	.....	Chiyoda	Chiyoda
		Sulfur Recovery	68 tons	$680,000	Planning	Dec 1962	.....	Chiyoda	Chiyoda
		H_2S Scrubber	171,000 lbs	$380,000	Planning	Dec 1962	.....	Chiyoda	Chiyoda
	Kawasaki	Stabilizer & Depropanizer	5,000 bbls	$280,000	Complete	.....	.....	Chiyoda	Chiyoda
		Atmospheric & Vacuum Crude Distillation	3,500 bbls	.....	Planning	June 1962	.....	Chiyoda	Chiyoda
Mitsubishi Petrochemical	Yokkaichi	Ethylene	22,000 tons/yr	.....	Complete	.....	S & W	S & W/JGC	JGC
		Polyethylene	15,000 tons/yr	.....	Under Constr	1961	BASF	BASF/Mitsubishi Chemical Machinery	Mitsubishi Chemical Machinery
		Polypropylene	10,000 tons/yr	.....	Under Constr	March 1962	Montecatini	Montecatini	Chiyoda
		Epoxy Resins	4,000 tons/yr	.....	Under Constr	Dec 1961	Shell	BICM	Mitsubishi Chemical Machinery
		Petroleum Resins	4,000 tons/yr	.....	Planning	Dec 1961	.....	.....	.....
		Alkylbenzene	15,000 tons/yr	.....	Planning	Dec 1962	UOP	UOP/Shell/JGC	.....
Mitsui Petrochemicals	Otake	Ethylene	20,000 tons/yr	.....	Engineering	Feb 1962	S & W	S & W/Mitsui Shipbuilding	Mitsui Shipbuilding
		Unifiner	1,700 bbls	.....	Planning	Feb 1962	S & W	S & W/Mitsui Shipbuilding	Mitsui Shipbuilding
		Acetaldehyde	24,000 tons/yr	.....	Engineering	Feb 1962	Hoechst	Uhde/JGC	JGC
		Hydrogen	.....	.....	Engineering	Feb 1962	Nippon Gas Chemical/ JGC	JGC	JGC
		*Unifiner	1,350 bbls	.....	Engineering	Feb 1962	UOP	UOP/JGC	JGC
	Ikuna	Acetaldehyde	.....	.....	Planning	.....	Aldehyde	Uhde	Uhde
Muroran Chemical	Muroran	*Alkar	17,250 tons/yr	.....	Engineering	1962	UOP	UOP/JGC	JGC
		*Styrene	15,000 tons/yr	.....	Engineering	1962	UOP	UOP/JGC	JGC
New Asia Oil	Yokohama	Unifiner	3,000 bbls	.....	Under Constr	1961	UOP	UOP/JGC	JGC
		Unifiner-Platformer	5,000 bbls	.....	Under Constr	1961	UOP	UOP/JGC	JGC
		Gas Concentration	1.6 MMcf	.....	Under Constr	1961	UOP	UOP/JGC	JGC
Nihon Synthetic Rubber	Yokkaichi	Exp. Petrochemicals	to 45,000 tons/yr	.....	Under Constr	1963	.....	.....	.....
Nippon Mining	Mizushima	Unifiner	2,000 bbls	.....	Under Constr	1961	UOP	UOP/JGC	JGC
		Unisol	2,500 bbls	.....	Under Constr	1961	UOP	UOP/JGC	JGC
		Cat Reforming	6,000 bbls	.....	Complete	.....	Houdry	Houdry	Houdry
		Hydrodesulfurization	8,000 bbls	.....	Under Constr	1961	.....	Catalytic/ Niigata	Catalytic/ Niigata
		Crude Distillation	30,000 bbls	.....	Under Constr	1961	.....	Fujinagata	Fujinagata
		Topping	30,000 bbls	.....	Complete	.....	.....	Fujinagata	Fujinagata
		No. 2 Unifiner	2,000 bbls	.....	Engineering	May 1962	UOP	UOP/JGC	JGC
Nippon Petroleum Detergent	Kawasaki	Detergent Alkylate	33,075 tons/yr	$5,000,000	Engineering	Early 1962	Cal Chemical	.....	.....
Nippon Petrochemicals/Oronite Chemical	Kawasaki	Alkyl Benzene	15,000 tons	$4,000,000	Engineering	Late 1961	Cal Research	Standard-Cal	Niigata
		Unifiner-Udex	822 bbls	$3,700,000	Under Constr	1961	UOP	UOP/JGC	UOP/JGC
		Ethylene	50,000 tons/yr	.....	Planning	Spring 1962	S & W	S & W/JGC	.....
Nippon Petroleum Refining	Yokohama	Cat Cracker	7,500 bbls	.....	Under Constr	Nov 1961	UOP	UOP/JGC	JGC
		*Unifiner	6,200 bbls	.....	Engineering	Oct 1962	UOP	UOP/JGC	JGC
	Kudamatsu	*Unifiner-Platformer	3,300 bbls	.....	Engineering	Aug 1962	UOP	UOP/JGC	JGC
Nippon Polyurethane	Tokuyama	*Toluene Diisocyanate	300 tons/mo	.....	Engineering	Aug 1962	Farbenfabriken Bayer	Farbenfabriken Bayer/JGC	JGC
Nitto Chemical Industry	Yokohama	Synthesis Gas	232 tons	$6,600,000	Engineering	May 1962	Texaco	Tears	Iino-Tears
	Kawasaki	*Detergent Alkylate	12,000 tons/yr	.....	Engineering	June 1962	UOP	UOP/JGC	JGC
Nitto Unicar	Kawasaki	Polyethylene	27,000 tons/yr	.....	Engineering	March 1962	.....	JGC	JGC
Okura Trading	Sendai	Catalytic Oil Gasification	0.75 MMcf	.....	Under Constr	Nov 1961	Onia Gegi	H & G	Ishii Iron
Osaka Gas	Kobe	Light Distillate & High Gas Reforming	7 MMcf	.....	Under Constr	Oct 1961	Onia Gegi	H & G	Ishii Iron
Shin Nippon Chisso Hiryo K.K.	Goi	Polypropylene	13,000 tons/yr	$20,000,000	Engineering	Fall 1962	Avisun	Tears	Iino-Tears
		*Propylene Purification	.....	$1,000,000	Planning	.....	.....	Tears	Iino-Tears
		*Polybutene	.....	$1,000,000	Planning	.....	Cosden	Tears	Iino-Tears
		Acetaldehyde	.....	.....	Planning	.....	Aldehyde	Uhde	Uhde
Showa Denko K.K.	Tokyo	Carbon Black	.....	.....	Under Constr	.....	Phillips	.....	.....
	Kawasaki	Acetaldehyde	.....	.....	Planning	.....	Aldehyde	Uhde	Uhde
		*Acetaldehyde	24,000 tons/yr	.....	Engineering	June 1962	Hoechst	Uhde/Staff/JGC	JGC
		*Propylene Glycol	6.5 tons	.....	Complete	.....	.....	.....	Chiyoda
		*Propylene Oxide	17 tons	.....	Complete	.....	.....	.....	Chiyoda
Showa Oil	Kawasaki	Unifiner-Platformer	6,000 bbls	.....	Under Constr	Oct 1961	UOP	UOP/JGC	JGC
		Merox	4,000 bbls	.....	Complete	.....	UOP	UOP/JGC	JGC
Sumitomo Chemical/ SBA	Niihama City	Acetylene-Ethylene	.....	.....	Engineering	.....	SBA	SBA	.....
		Ethylene	25,000 tons/yr	.....	Engineering	.....	S & W	.....	.....
		Unifiner-Udex	1,000 bbls	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
		Alkylbenzene	10,000 tons/yr	.....	Planning	.....	UOP	.....	.....
	Ohe	*No. 2 Ethylene	40,000 tons/yr	.....	Under Constr	Feb 1962	S & W	S & W/JGC	JGC
		*Detergent Alkylate	10,000 tons/yr	.....	Engineering	Sept 1962	UOP	UOP/JGC	JGC
Toa Nenryo	Kawasaki	Fired Heater	1.8 MM Btu/hr	$6,500	Complete	.....	.....	Tears	Iino-Tears
		*Desalter	60,000 bbls	.....	Under Constr	Jan 1962	Petreco	Petreco/Chiyoda	Chiyoda
Toa Oil	Kawasaki	Desalter	30,000 bbls	$100,000	Engineering	1961	Petreco	Petreco/Chiyoda	JGC/Chiyoda
		Merox	5,000 bbls	.....	Under Constr	Dec 1961	UOP	UOP/JGC	JGC
		Unifiner-Platformer	5,000 bbls	.....	Under Constr	March 1962	UOP	UOP/JGC	JGC
		Gas Concentration	14,000 lbs/yr	.....	Under Constr	March 1962	.....	JGC	JGC
Tokai Ryuan K.K.K.	.....	High Pressure H_2S & CO Conversion, CO_2 Removal	500,000 cu ft/hr	.....	Engineering	.....	Power-Gas/ Ventrocoke	Power-Gas	Mitsubishi KK
Tonen Petrochemicals	Kawasaki	Butadiene	18,742 tons/yr	.....	Under Constr	March 1962	Esso	Chiyoda/Staff	Chiyoda/Staff
		Ethylene	40,000 tons/yr						
		Butadiene	7,000 tons/yr	$25,000,000	Under Constr	1962	Esso	Esso/Staff	Staff
Toshiba Electric	Himeji	Catalytic Oil Gasification	0.5 MMcf	.....	Under Constr	Dec 1961	Onia Gegi	H & G	Ishii Iron
Toyo Koatsu	Muroran	Alkar	17,250 tons/yr	.....	Planning	May 1962	UOP	UOP	.....
		Styrene	15,000 tons/yr	.....	Planning	May 1962	UOP	UOP	JGC
Ube Kosan	.....	Ammonia	100 tons	.....	Under Constr	.....	.....	Chemico	Chemico
		Ethylene	21,000 tons/yr						
		Polyethylene	20,000 tons/yr	.....	Planning	.....	.....	.....	.....
		Polypropylene	5,000 tons/yr						
	Chiba	Alkylbenzene	10,000 tons/yr	.....	Planning	.....	UOP	.....	.....
		*Detergent Alkylate	10,000 tons/yr	.....	Planning	.....	UOP	.....	.....

*First appearance in tabulation.

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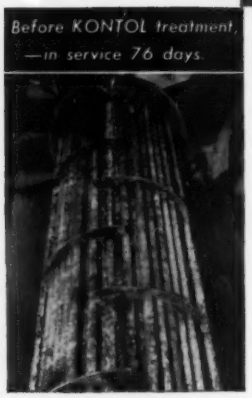
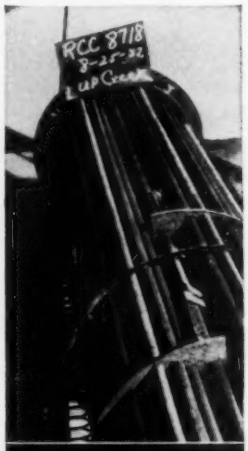
TRETOLITE SERVICE report

Midwestern refinery "saves a bundle" with KONTOL* *Corrosion Inhibitor*



Before KONTOL treatment, —in service 76 days.



After 295 days' service, with KONTOL treatment.

Both ways—in dollars and in actual equipment—this refinery "saved a bundle" in its crude unit heat exchange section by adopting a KONTOL* protection program.

Heat exchange was inefficient and tube life was short. Then KONTOL Corrosion Inhibitor was injected into the overhead line ahead of the condensers.

Here are the bundle-saving results:

- Tube bundle life was *tripled* by drastic curtailment of corrosion.
- Heat savings amounted to *6,000,000 BTU's per hour*, as a result of KONTOL's powerful detergent action.
- Estimated cost of heat loss was $96 per day prior to use of KONTOL. KONTOL protection eliminated this loss for only $20 per day—a savings of nearly 5 times the cost.

KONTOL Corrosion Inhibitors are protecting tube bundles, and saving bundles of money, for refiners all over the world. Ask your Tretolite Field Service Engineer (the "Man in the Red Car") for more details.

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ITALY, Rome • **JAPAN**, Tokyo • **KUWAIT**, Kuwait • **MEXICO**, Mexico, D. F.
NETHERLANDS, The Hague • **TRINIDAD**, Port of Spain

FA-60-3A

HPI CONSTRUCTION BOXSCORE—*Continued*

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
KOREA									
Korean Government..	Naju	Urea	95,000 tons/yr	.....	Under Constr	1962	Inventa	Lurgi/Uhde	Lurgi/Uhde
Korea Petroleum.....	Ilsan	Refinery	20,000 bbls	.....	Planning	.....	.....	.....	.....
MALAYA									
Maruzen Toyo Oil (Singapore)	Pasir Panjang	Refinery	20,000 bbls	.....	Under Constr	Dec 1961	.....	.....	.....
Shell Refining (Malaya)	Port Dickson	Refinery	20,000 bbls	.....	Planning	Mid 1964	.....	.....	.....
Shell Refining (Singapore)	P. Bukom	Refining	20,000 bbls	.....	Under Constr	1961	.....	.....	.....
Standard Vacuum....	Port Dickson	Refinery, Chemical Fertilizers	.....	.....	Planning	1964	.....	Lummus	Lummus
THAILAND									
Thai Defense Ministry	Bangkok	Refinery	5,000 bbls	$20,000,000	Engineering	July 1962	Houdry/ Phillips	Hydrocarbon	Japanese Fuji

Australasia

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
AUSTRALIA									
Australia Lubricating Oil Refinery	Kurnell	Vacuum Distillation	.....	.....	.....	.....	.....	.....	.....
		Furfural Extraction	140,000 tons/yr	.....	Engineering	.....	Texaco	Foster Wheeler	Staff
		Hydrotreating	.....	.....	.....	.....	.....	.....	.....
		MEK Dewaxing	.....	.....	.....	.....	.....	.....	.....
Australian Synthetic Rubber	Altona	Synthetic Rubber	30,000 tons/yr	$10,000,000	Under Constr	1961	Goodyear	Fluor	Fluor/Utah
Bitumen & Oil Refineries	Sydney	Diesel Unifiner	2,500 bbls	.....	Under Constr	.....	.....	UOP	Staff
		Crude	12,000 bbls	.....	Planning	.....	.....	Procon	Procon
	Matraville	Udex	1,000 bbls	$1,000,000	Under Constr	1961	UOP	Procon	Procon
		Cat Cracking, Concentration Polymerization	4,500 bbls	$4,000,000	Under Constr	Dec 1961	UOP	Procon	Procon
British Petroleum....	Kwinana	Lube Oils	100,000 tons/yr	.....	Engineering	End 1962	Texaco	Foster Wheeler/ CJB	Foster Wheeler/ CJB
CSRC Dow Pty.....	Altona	Styrene	.....	$6,500,000	Under Constr	1961	Dow	Bechtel/McDonald/Wimpey & Coy	Bechtel/McDonald/Wimpey & Coy
		Ethylene Dichloride	.....	.....	Under Constr	1961	.....	Bechtel/ McDonald/ Wimpey	Bechtel/ McDonald/ Wimpey
Fremantle Gas.....	Fremantle	*Catalytic Oil Gasification	2.8 MMcf	.....	Engineering	End 1962	Onia Gegi	H & G	H & G
Gas & Fuel.....	Melbourne	Catalytic Oil Gasification & Gas Reforming	10 MMcf	.....	Under Constr	1962	Onia Gegi	H & G	H & G
Geelong Gas.....	Geelong	Refinery Gas Reforming	3 MMcf	.....	Complete	.....	Onia Gegi	H & G	H & G
Shell Chemical.....	Clyde	Resins, Alkylates	.....	$22,000,000	Planning	.....	.....	.....	.....
		Cat Cracker	.....	$38,000,000	Under Constr	1963	.....	.....	.....
		Ethylene	.....	$22,400,000	Under Constr	Early 1962	.....	Braun	Braun
Shell Refining (Australia)	Newport	Oil Blending	.....	.....	.....	.....	.....	.....	.....
	Clyde	Cat Cracker	24,000 bbls	.....	Under Constr	Late 1962	.....	.....	.....
	Geelong	Hydrodesulfurizer	11,000 bbls	.....	Planning	.....	.....	.....	.....
Standard Vacuum....	Altona	Petrochemicals (Ethylene & Butadiene)	20,000 tons/yr	$28,000,000	Under Constr	1961	Esso	Fluor	Fluor/Utah
	Port Noarlunga, near Adelaide	Refinery: Crude Splitter, Vacuum Still, Hydrodesulfurization, Cat Reforming, Sulfur Recovery	37,800 bbls	$30,000,000	Engineering	Early 1963	.....	Kellogg	Kellogg
Union Carbide.....	Melbourne	Polyethylene	15,000,000 lbs/yr	$6,500,000	Under Constr	1961	.....	.....	.....
NEW ZEALAND									
New Zealand Refining (BP, Caltex, Europa, Shell, Stanvac)	Whangerei	Crude Distillation, Cat Reforming, Gas Oil Desulfurization, Bitumen	50,000 bbls	.....	Planning	.....	.....	.....	.....
PHILIPPINE ISLANDS									
Filoil Refining.....	Luzon	Refinery	10,000 bbls	.....	Planning	.....	.....	.....	.....
Shell (Philippines)....	Manila	Refinery	25,000 bbls	.....	Under Constr	1962	.....	Bechtel	Bechtel
	Tabangao	Refinery	25,500 bbls	.....	Under Constr	Mid 1962	.....	.....	.....

*First appearance in tabulation.

Boxscore Abbreviations

Badger N. V.—Badger N. V., Netherlands
Badger Mfg.—Badger Mfg. Co.
B & R—Brown & Root, Inc.
BASF—Badische Anilin & Sod. Fab.
Bechtel—Bechtel Corp.
Blaw-Knox—Blaw-Knox Co.
Braun—C F Braun Co.
Cal Research—California Research Corp.
Canadian Badger—Canadian Badger Company Limited
Canadian Bechtel—Canadian Bechtel Limited
Catalytic—Catalytic Construction Co.
Chemico—Chemical Construction Co.
Chiyoda—Chiyoda Chemical Engineering & Construction Co.
C&I—The Chemical and Industrial Corp.
CJB—Constructors John Brown, Ltd.
CTIP—Compagnia Technica Industria Petroli
Dresser—Dresser Engineering Corp.
Ehrhart—Ehrhart & Associates, Inc.
ERI—Etudes et Recherches Industrielles S.A.
Esso—Esso Research and Engineering Co.
Fluor—Fluor Corp.
Food—Food Machinery & Chem. Corp.
Foster Wheeler—Foster Wheeler Corp.
Fried. Krupp—Fried. Krupp Industriebau
FSB—Fluor Singmaster & Breyer, Inc.
Girdler—The Girdler Corp.
Heurtey—Societe Anonyme Heurtey
H & G—Humphreys & Glasgow
Hudson—Hudson Engineering Corp.
Hydrocarbon—Hydrocarbon Research, Inc.
ICI—Imperial Chemical Industries, Ltd.
Iino-Tears—Iino Shipbuilding & Engineering Co., Ltd., and Tears Engineers, Inc.
JGC—Japan Gasoline Co.
Kellogg—The M. W. Kellogg Co.
Kidde Constr.—Walter Kidde Constructors, Inc.
Kidde Engrs.—Walter Kidde Engineers Southwest, Inc.
Koppers—Koppers Co., Inc.
Litwin—Litwin Engineering Co.
Lummus—The Lummus Co.
Lurgi—Lurgi G. m. b. H.
McKee—Arthur G. McKee Co.
MHW—McKee Head Wrightson, Ltd.
Nofsinger—The C. W. Nofsinger Co.
Olsen—O. L. Olsen Co.
Otto—Dr. C. Otto & Comp., G. m. b. H.
Parsons—The Ralph M. Parsons Co.
Pona—Pona Engineers, Inc.
Power-Gas—Power Gas Corp., Ltd.
Pritchard—J. F. Pritchard Co.
Procon—Procon, Inc.
Ref-Chem—Refinery Chemical Co.
S&W—Stone & Webster Engineering Corp., Chemical Division
S&W Ltd.—Stone & Webster England, Ltd.
SBA—Soc. Belge de L'Azote et des Produits Chimiques du Marly
SD—Scientific Design
SFST—Societe Francais des Services Techniques
Stearns-Roger—Stearns-Roger Mfg. Co.
STEC—Societe Technique D'Entreprises Chimiques
Sweco—Southwestern Engineering Co.
Tears—Tears Engineers, Inc.
Technip—Compagnie Francaise D'Etudes et de Construction TECHNIP
Tellepsen—Tellepsen Petro-Chem Constructors
Treco—Refinery Engineering Co.
Uhde—Friedrich Uhde, G. m. b. H.
UOP—Universal Oil Products Co.
Vulcan—Vulcan Cincinnati, Inc.

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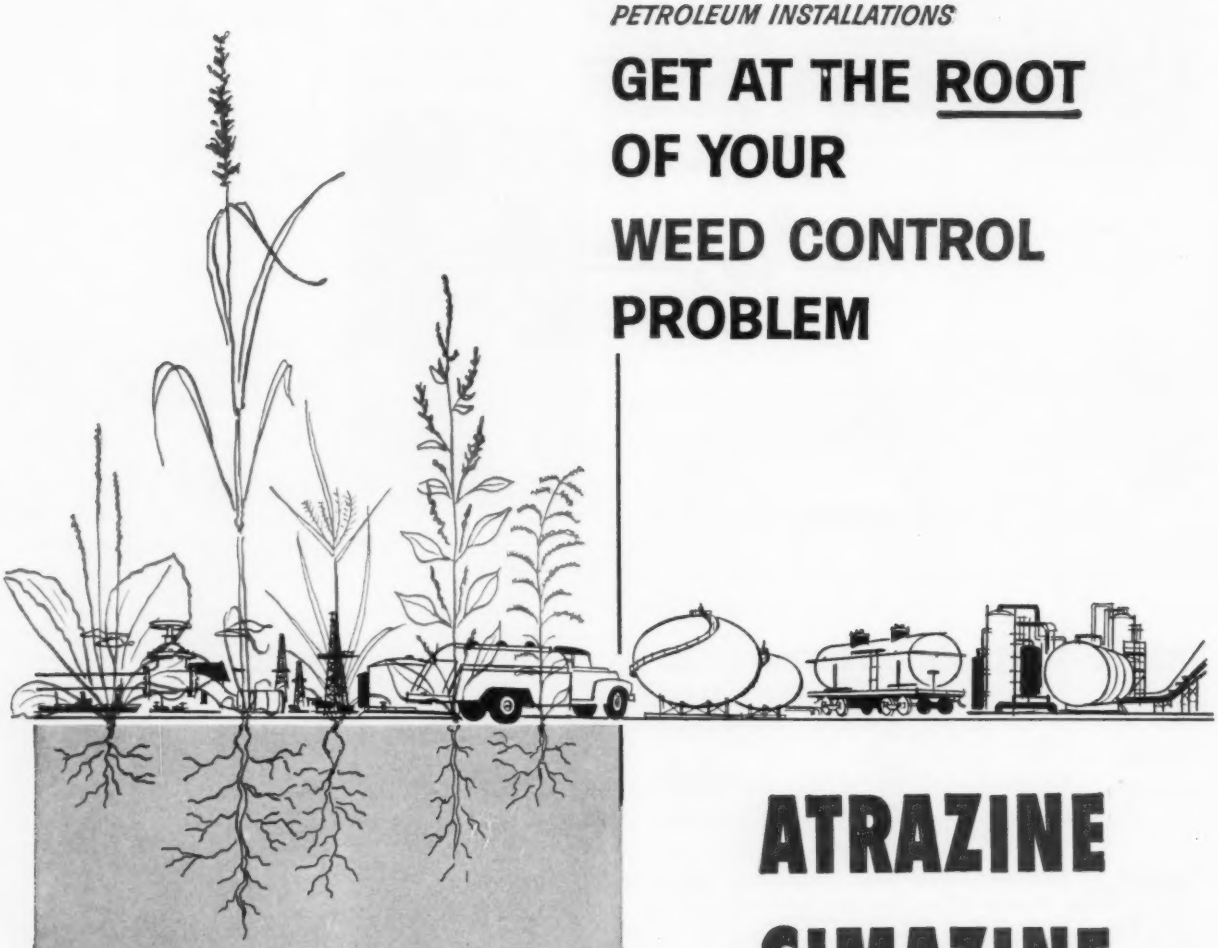

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What's Happening

Continued from Page 45

GOVERNMENT

Tighter rope for anti-trust

Stronger anti-trust laws are aim of administration, and several bills will be getting attention at next session of Congress, in 1962. (See "More Teeth for Trustbusters," August issue, page 180.) Attorney General Robert Kennedy is said to be especially interested in a plan to give Justice Department authority to issue a subpoena when investigating possible civil anti-trust violation. At present, only Federal Trade Commission has this power.

Kennedy's charge: In recent years, many businessmen have refused to negotiate with Justice Department over possible violations in their respective companies. He further adds that the "situation is getting increasingly worse." The big corporate fear: That new proposal would lift present veil of secrecy from corporate record—encourage Government "witch hunt" for violators.

Change in import plan

Total allowable imports at about 11 percent of demand for domestic crude, instead of current 9 percent in Districts 1—4, is substance of new preliminary draft being completed by U.S. Interior Department oil specialists. Change in import plan for total allowables probably will result in 25,000 to 50,000-bpd cut, depending upon final percentage figure recommended. Relation of imports ratio solely to domestic crude demand may present possibility of error, according to some government oil experts.

- Changing Times -

Petroleum refiners in United States and Canada will spend over $4.5 million on asphalt research this year, reports Asphalt Institute. U. S. and Canadian companies showed $4,412,700 budgeted for product research in 1961.

"By fourth quarter of this year, gross national product should be running at annual rate of $537 billion," according to A. J. Ashe, director of business research, B. F. Goodrich. "This is compared to about $500 billion during first quarter and $515 billion in second quarter," Ashe added.

Kerr-McGee Oil Industries' Cushing, Okla., refinery is concentrating on making high-quality lubricating oils and curtailing gasoline and fuel oil manufacture. Firm's president, D. A. McGee cites reasons for action: high crude costs, low market prices and obsolete gasoline and fuel oil making facilities.

Oil changes every 4,000 miles is being recommended by Chrysler Corp. for its 1962 models, instead of 6,000-mile interval suggested by some auto makers. API's recommendation is for oil changes at least every 2,000 miles.

Asphalt Institute gains new member—Champlin Oil & Refining, Fort Worth. Champlin is among 57 other asphalt refiners in institute.

An early Smithco process cooler.

Because of the faith and actions of a handful of process engineers and plant owners in the early days, almost all modern refinery and petrochemical plants today employ air cooled heat exchangers. The enthusiasm for air cooling generated by these single-minded individuals spread rapidly once performance records of actual installations were evaluated and comparative studies made. Now, because of the confidence of these men and the high standard of performance attained by these early units, air is being called upon to answer an unlimited variety of process cooling requirements.

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Meetings Calendar

October

12-13.....**California Natural Gasoline Association,** Annual Fall Meeting, Lafayette Hotel, Long Beach, Calif.

13-14.....**E. P. Schoch Lecture Series,** Union Auditorium, The University of Texas, Austin, Texas.

-16.....**American Society of Safety Engineers,** Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

-20.....**American Institute of Chemical Engineers,** South Texas Section, Moody Civic Center, Galveston, Texas.

23-26.....**National Association of Corrosion Engineers,** South Central Region Conference and Exhibition, Shamrock Hilton Hotel, Houston, Texas.

23-28.....**Institute of Chemical Engineers of Puerto Rico,** First Inter-American Congress of Chemical Engineering, San Juan, P. R.

24-26.....**NACE,** South Central Regional Conference and Exhibition, Houston, Texas.

25-26.....**Armour Research Foundation,** Computer Applications Symposium, Morrison Hotel, Chicago, Ill.

25-26.....**National Petroleum Refiners Association,** Annual Question and Answer Session on Refining Technology, Rufus Garrett Hotel, El Dorado, Ark.

-27.....**AIChE,** Northwest Regional Meeting, Student Union Building, University of Washington, Seattle, Wash.

-27.....**Natural Gas Processors Association,** Southern Regional Meeting, Carlton Hotel, Tyler, Texas.

29-Nov. 1.....**National Lubricating Grease Institute,** Annual Meeting, Rice Hotel, Houston, Texas.

30-Nov. 1.....**American Oil Chemists' Society,** Fall Meeting, Pick-Congress Hotel, Chicago, Ill.

November

1- 3.....**Industrial Management Society,** Industrial Engineering and Management Clinic, Pick-Congress Hotel, Chicago, Ill.

6- 8.....**Chemical Institute of Canada,** Chemical Engineering Division Conference, Royal York Hotel, Toronto, Ont.

8-11.....**Institute of Management Sciences,** Second American Meeting (Joint with Operations Research Society of America), Jack Tar Hotel, San Francisco, Calif.

9-10.....**Society of Automotive Engineers,** National Fuels & Lubricants Meeting, Shamrock Hilton Hotel, Houston, Texas.

13-15.....**American Petroleum Institute,** Annual Meeting, Conrad Hilton Hotel, Chicago, Ill.

-17.....**NGPA,** Panhandle Plains Regional Meeting, Herring Hotel, Amarillo, Texas.

26-Dec. 1.....**American Society of Mechanical Engineers,** Winter Annual Meeting, Statler Hilton Hotel, New York, N. Y.

27-Dec. 1.....**Exposition of Chemical Industries,** New York Coliseum, New York, N. Y.

December

3- 6.....**AIChE,** Annual Meeting, Hotel Commodore, New York, N.Y.

5- 6.....**NPRA,** Computer Conference for Refiners, Hotel Tulsa, Tulsa, Okla.

1962

January

8-12.....**SAE,** Annual Meeting, Cobo Hall, Detroit, Mich.

-19.....**NGPA,** Gulf Coast Regional Meeting, Robert Driscoll Hotel, Corpus Christi, Texas.

March

-16.....**NGPA,** Oklahoma Regional Meeting, Sheraton-Oklahoma Hotel, Oklahoma City, Okla.

18-22.....**NACE,** Meeting, Municipal Auditorium, Kansas City, Mo.

20-29.....**American Chemical Society,** National Meeting, Washington, D. C.

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Men in HPI...

Morgan J. Davis has been elected chairman of the board, Humble Oil & Refining Co. **Carl E. Reistle, Jr.,** formerly executive vice president, has

Davis

Reistle

been named to succeed Davis as president. Davis joined Humble in 1925 after his graduation from The University of Texas. Reistle, a graduate of the University of Oklahoma, joined the company in 1936.

Fred C. Boucke has been appointed assistant to the chairman of the board, Standard Oil Co. of California. He has been in London as president, Iran California Oil Co., subsidiary which manages Standard's 7-percent interest in the Iranian Oil Consortium. Boucke will be succeeded as Irancal's president by **E. Perrin Fay,** previously assistant manager of Standard's Eastern Hemisphere operations staff. Boucke joined the company in 1937.

R. Jack Hawes, former supervisor of technology at Tidewater Oil Co.'s Delaware refinery, has been promoted to superintendent of technology. He succeeds **Dr. Arthur W. Lewis,** who has been assigned to the company's home office in Los Angeles. Hawes joined Tidewater in 1929 as an engineer, Development Department, at the former Bayonne, N.J., refinery.

Bernard J. Williams has been named project manager, SunOlin Chemical Co.'s engineering staff. Williams is in charge of engineering for all of the auxiliary plants connected with SunOiln's $20-million ethylene and ethylene oxide plants now under construction at Claymont, Del. He succeeds **Thomas G. Reynolds,** who has resigned to join Thatcher & Patient, Inc., St. Louis, Mo., consulting engineers. Williams joined SunOlin in October 1960 from Brown & Root, Inc., Houston, where he was a project engineer for four years.

W. T. Maddock, a senior refining engineer with The Ohio Oil Co., has been named assistant to **B. B. Miller,** who was recently appointed Ohio Oil's refinery representative in Europe. Maddock will make his headquarters in Europe after Jan. 1, 1962. He joined Ohio Oil as a process engineer at the Robinson, Ill., refinery in 1948.

Vincent N. Hurd has been promoted to manager, Petrochemicals Department, Gulf Eastern Co. in London. Hurd has been director of technical development, Petrochemicals Department, in the headquarters office of Gulf Oil Corp. in Pittsburgh. He will be responsible for petrochemicals activities in Europe and other areas of the Eastern Hemisphere.

Edward N. Heger has been named manager of chemical manufacturing, Ansul Chemical Co., Marinette, Wis. **Charles F. Abendschein** has been made plant manager of Ancon Chem-

Heger

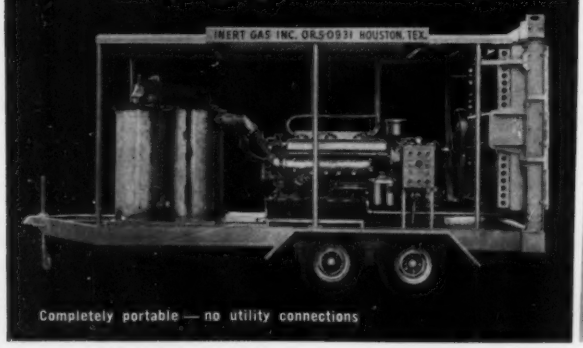
Abendschein

ical Corp.'s Lake Charles, La., plant. Ancon is jointly owned by Ansul and Continental Oil Co. Heger joined Ansul in 1956 as a chemical engineer. Abendschein came to the firm in 1946.

Neil R. Amundson, professor and head, Department of Chemical Engineering, University of Minnesota, has been named 1961 winner of the William H. Walker Award, presented annually by the American Institute of Chemical Engineers. Other AIChE awards go to **Dr. Thomas Baron,** director of basic and general engineering, Shell Development Co., and **Dr. G. R. Moore,** also of Shell Development. Dr. Baron is recipient of the Professional Progress Award in Chemical Engineering; Dr. Moore, the Allan P. Colburn Award.

L. L. Henning, formerly president and general manager, Irving Refining, Ltd., St. John, N. B., has been

Cut purging and blanketing costs with Non-X* produced on the spot!



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Are you one who says

"What the heck... all Raschig Rings are alike!"

If you are — you'll be interested in the two tables shown in this ad. We had our engineering department purchase several cubic feet of 1" porcelain raschig rings from our two principal competitors — asked Stoneware research to compare them with ours. The tables give the answers.

Two points stand out to the buyer of raschig rings who wishes to get the most for his money. (1) The lower packing factor of our rings results in a pressure drop 15% - 20% lower which means greater capacity for your tower, or lower pumping costs. (2) The longer service life of our rings in corrosive service not only saves on replacement costs but assures maintenance of low pressure drops for a longer period.

There are good reasons for our better quality. The porcelain body from which our rings are made has been developed solely for this type of service. It has no porosity. It is extruded through Alite high alumina dies which assures uniform wall thickness. It is fired under precisely controlled conditions. The result is the best porcelain raschig ring available anywhere in the world.

	Our 1" O.D. Rings	Mfr. "A" 1" Rings	Mfr. "B" 1" Rings
Wall thickness	0.130"	0.162"	0.165"
Surface Area (Sq. ft. per cu. ft. of packing)	57.6 sq. ft.	56.0 sq. ft.	55.6 sq. ft.
Weight per cu. ft.	42 lb.	51 lb.	50 lb.
Free Space	72.5%	66.3%	67.0%
Packing Factor	160	207	203

	Our Porcelain Rings (1"x1"x⅛")	Mfr. "A" Rings (Thicker Walls)	Mfr. "B" Rings (Thicker Walls)
Weight change after 2 weeks in boiling 72% H_2SO_4	0.44	1.40	8.4
Ditto after 4 weeks	0.93	5.60	*
Breaking strength in lbs. of new rings before acid boiling test	130	144**	191**
Breaking strength in lbs. AFTER 4 weeks in boiling H_2SO_4	134	75	*

*Mfr. "B's" rings fell apart during the third or fourth week, preventing us from getting any further weight or strength data.

**Rings of both Mfr. "A" and Mfr. "B" are naturally stronger when shipped, because of their substantially thicker walls.

When you're tempted to save a few cents per cubic foot by buying a lower cost ring, remember you'll be dollars ahead by buying ours.

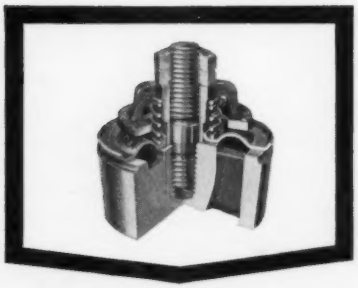
PROCESS EQUIPMENT DIVISION

U. S. STONEWARE

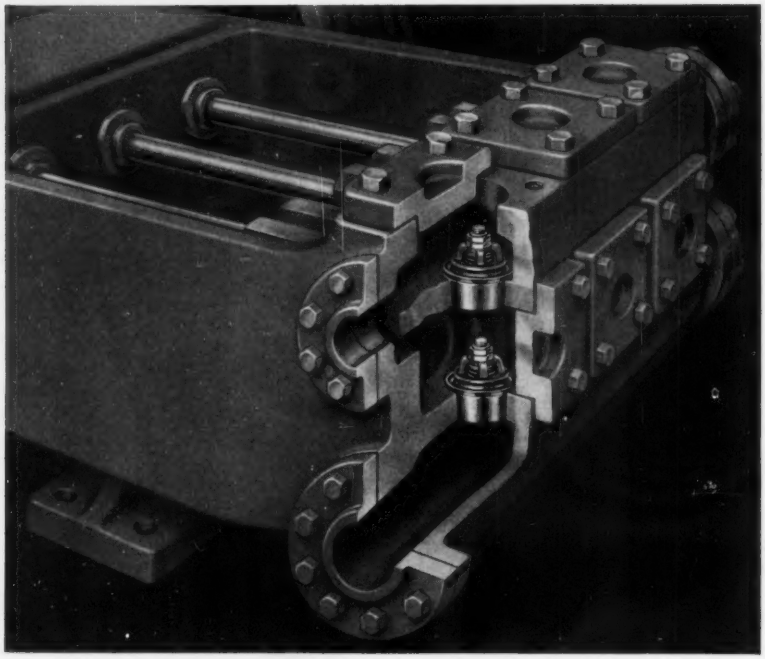
AKRON 9, OHIO

64-H

fast valve action



points the way to high-speed pump efficiency



DURABLA Valves are ideally suited to modern high-speed reciprocating pumps. One big reason: Valve action is very sharp, thanks to a light-weight, free-moving member.

Formed from thin, non-corrosive metal, the valve member is designed to make but "point contact" on the sleeve. This unique feature, together with the patented arched design, makes it the freest moving and most durable valve available. Will never warp, bind or hang up.

Quick and easy inspection of working parts (without the necessity for stud or seat removal) is possible due to a self-locking nut and drop-on guard. The taper-lock stud can be screwed down tight into the seat without danger of galling or breakage . . . there is no excuse for overstressing no matter how many times it is removed and then returned to position.

A credit to new pumps, DURABLA Valve Units are also widely used to re-valve older pumps. Come in 15 sizes, designed to meet over 300 variations in installation requirements.

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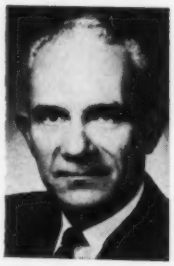
DM-39

Men . . .

named general manager, Standard Oil Co. of California's 100,000-bpd refinery project at Pascagoula, Miss. Henning has also been manger, Standard-California's Bakersfield, Calif., refinery. **A. S. Guerard,** former chief engineer at Stancal's Richmond, Calif., refinery, has been appointed assistant general manager of the project. **B. I. Roach** has become planning assistant at Pascagoula.

Bert B. Miller, assistant to the president, The Ohio Oil Co. since 1958, has become the company representative in Madrid, Spain. Compania Iberica Refinadora de Petroleos S.A., owned by the Spanish government, other Spanish interests and Ohio Oil, soon will begin construction of a 25,000-bpd refinery on the northern coast of Spain. Miller will handle Ohio Oil's interests in the construction and operation of the new refinery.



Miller

Dr. L. deVries has been promoted to senior research chemist, petroleum products research section, Richmond Laboratory, California Research Corp.

Donald A. Brenner has joined the Whiting, Ind., research laboratories, American Oil Co. He will investigate the economics of new petroleum refining processes and those of existing processes in new applications.

E. A. Nollkamper has been named plant foreman, Shell Oil Co.'s Sealy, Texas, gasoline plant now under construction. With Shell 15 years, he joined the company as a maintenance mechanic, Sheridan, Texas, gas recycling plant.

Drs. F. W. Lampe, John Dahlar and L. W. Morgan, three college professors, served as consultants with Humble Oil & Refining Co. this past summer at Baytown, Texas. Drs. Lampe and Dahlar worked in research and development, while Dr. Morgan conducted sessions on process control and consulted on instrumen-

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modern joints you can

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Now you can say..

goodbye to leaky threads C-E joints welded into loading arms eliminate excessive maintenance costs caused by dripping caustic fluids.

goodbye to costly flanges C-E weldable joints eliminate need for flanged connections when fabricating loading arms.

goodbye to higher installation costs C-E weldable joints are easier and faster to install, lower priced and stronger, too.

goodbye to time-consuming packing replacement C-E weldable joints can be repacked when necessary without removal from loading arms.

Continental-Emsco's patented design permits bearings to remain in place *even during* packing replacement or adjustment. Simply loosen set screws and turn body. Joints break like a union, exposing *only* the packing . . bearings are *never* disturbed. Wide spacing of high capacity bearings . . another exclusive C-E feature . . permits greater foot-pound loading on the joint. Additional features include on-location replacement of worn parts . . elimination of split bearing races for added strength . . reversible races on most joints for double service life.

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C-E joints are manufactured for practically all petrochemical and chemical services. Sizes are available from 3/8" to 12" diameter in steel . . from 2" to 12" diameter in aluminum. Joints are also available in threaded or flanged styles for replacement in existing systems.

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Experience	Three-quarters of a century—longest of any Company in the field.

*Partial list of products. Most are available in economical powder or easy-to-use briquette form.

Unfortunately, there's no panacea—no universal cure-all—for industrial water treatment problems.

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Men . . .

tation. Dr. Lampe is with the Chemistry Department, Pennsylvania State University; Dr. Dahlar teaches at the University of Minnesota, Chemical Engineering Department; and Dr. Morgan is in the Petroleum Refining Engineering Department, Colorado School of Mines.

James K. Warne has been made general manager, Gulf Oil Corp's Philadelphia refinery, succeeding **Thomas A. Dietz,** who has been transferred to the Pittsburgh general office on a temporary assignment. Dietz had been general manager since 1957. Warne, who had been manager, engineering, Philadelphia refinery, since 1959, started with Gulf in 1945 as a field engineer in Philadelphia. **Karl K. White,** director, design and construction, Philadelphia refinery, since 1959, will succeed Warne. He has been with Gulf since 1935. **Jack W. Burk,** superintendent, Cracking Department, Philadelphia refinery, will become manager, operations, at the plant.

Warne

Dietz

White

Burk

William F. Brown, Houston, manager of Continental Oil Co.'s petrochemical planning, has been promoted to Conoco's International Department staff, with headquarters in New York. **Wyatt L. Walker,** Ponca City, Okla., assistant superintendent of the Ponca City refinery, has been made

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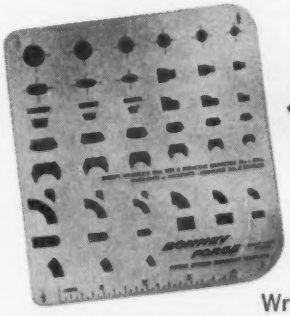

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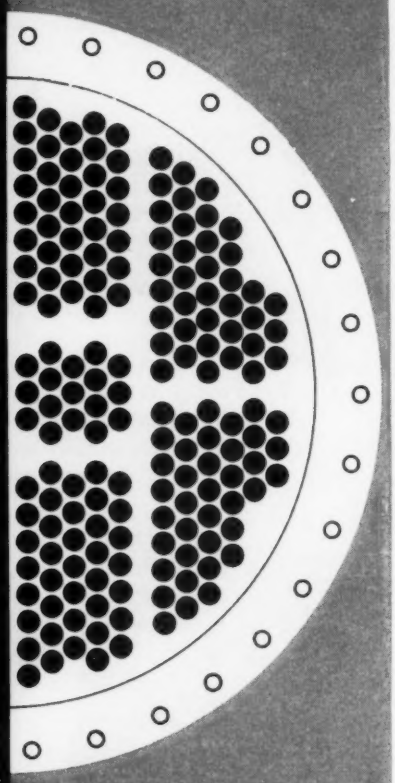

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The ALONizing process deeply diffuses aluminum into the steel to form an iron-aluminum protective alloy with mechanical properties provided by the base steel. This resultant duplex structure offers excellent oxidation and corrosion resistance at temperatures even beyond 1600° F.

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Men . . .

manager of petrochemical planning, Petrochemical Department, with headquarters in Houston. He succeeds Brown. **Norman Newton** has been named to replace Walker as assistant superintendent, Ponca City plant. Newton was refinery superintendent at Wichita Falls, Texas.

William E. Lifson has been appointed by Esso Research and Engineering Co. to deputy to the vice president, petroleum products, medical research and analytical and basic research.

B. M. O'Brien and B. S. Shapiro along with **Drs. R. R. Buntin** and **J. R. Reed** have joined Humble Oil & Refining Co.'s Research and Development Division, Baytown, Texas.

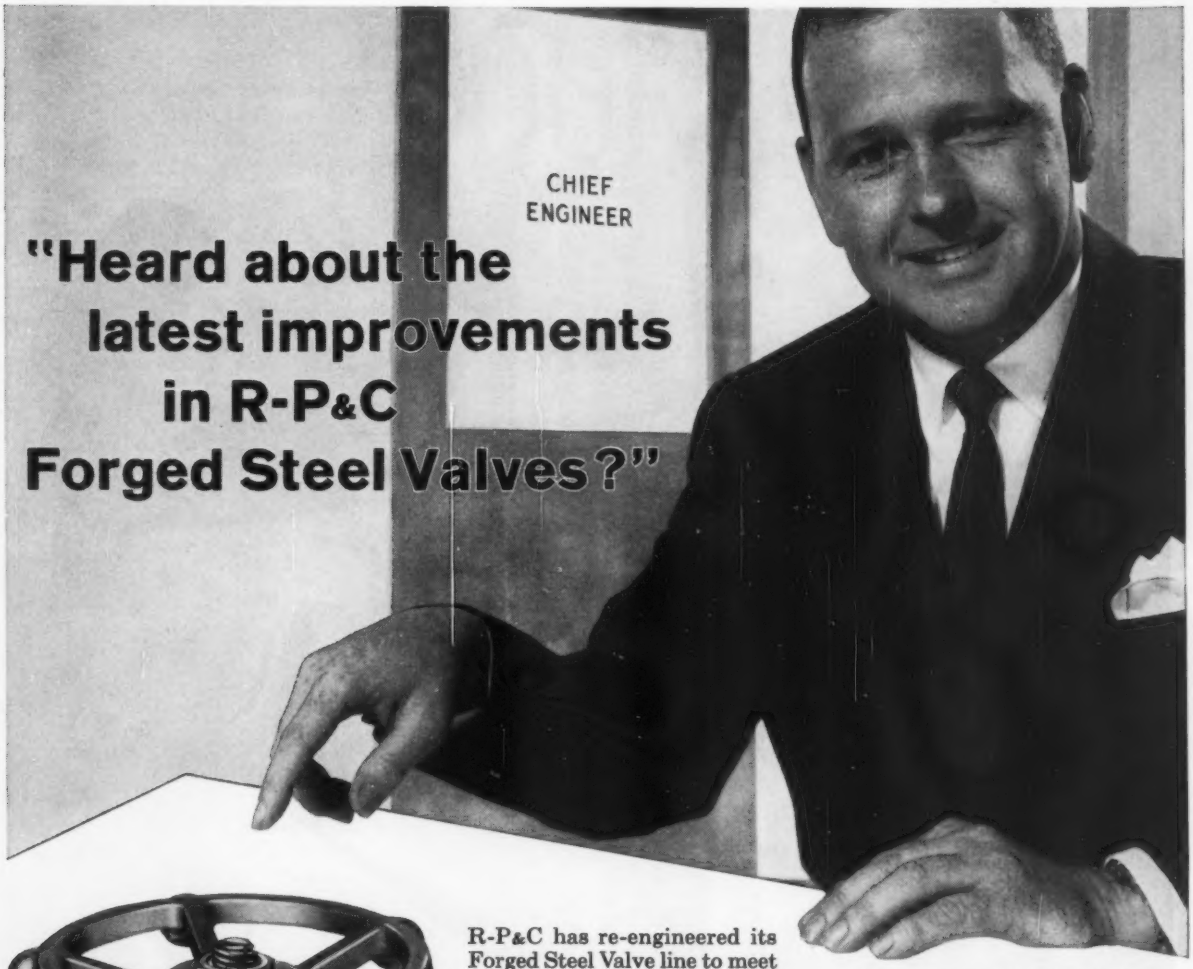
Lance Jeffers has joined the Public Relations Department, American Oil Co., as a staff writer in the general office, Chicago. He formerly taught English at Howard University and Tuskegee Institute.

Robert O. Spurdle has been appointed patent advisor, Research and Engineering Department, Sun Oil Co. **George L. Church** has been named to succeed Spurdle as director of Sun's Patent Division.

Sidney P. Thomas has been appointed construction superintendent for Monsanto Chemical Co.'s Chocolate Bayou project, near Alvin, Texas, after serving as director of engineering for Mobay Chemical Co., Pittsburgh, a Monsanto associate.

David C. Liu has become a partner with Dames & Moore, consultants in applied earth sciences. Liu was made manager of the firm's Honolulu office when it was opened in 1960.

J. E. Beavers has become assistant superintendent of joint plants, Gasoline Division, Cities Service Petroleum Co., Bartlesville, Okla. **Guy W. Duren** replaces Beavers as superintendent of area 3, which includes plants in Louisiana, East and South Texas. **Frank M. Allen** of Blackwell, Okla., superintendent of the Ambrose gasoline plant there, has been promoted to superintendent of area 2, which consists of plants in West



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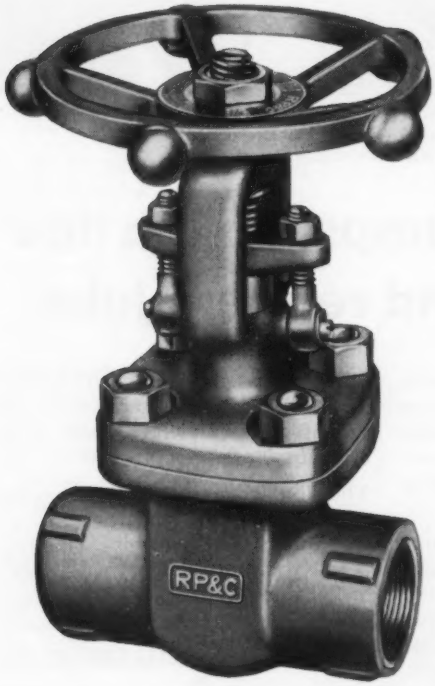

R-P&C has re-engineered its Forged Steel Valve line to meet the highest standards of quality for the Refinery, Chemical, Power and Process industries. These valves incorporate the most up-to-date design and material improvements found in any forged steel valve! One example is the stuffing box—redesigned for 50% greater sealing efficiency. These improvements add up to longer, trouble-free valve service for you, with minimum maintenance.

Here are other R-P&C Forged Steel Valve improvements:

- **Stellite-faced seats, lapped to 2-3 micro-inch finish; results in a durable seal**
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- **"390 Brinell" stem with rolled threads for continuously smooth movement**
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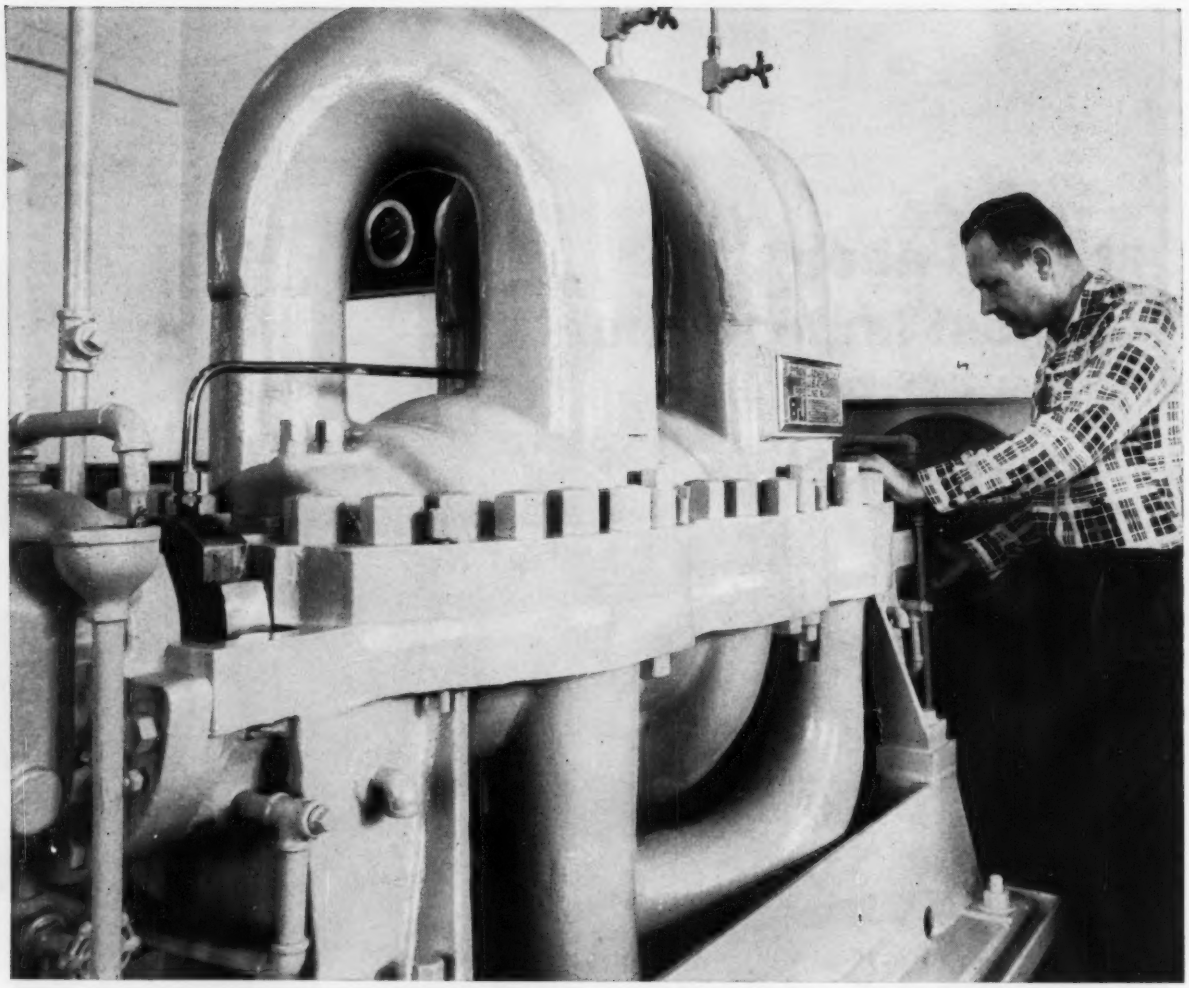

This Byron Jackson six stage centrifugal pump uses Type 1 Ni-Resist iron for stage pieces, bushings, cage rings, and wear rings. These parts help the Eastern Pipe Line Division of the Atlantic Pipe Line Company keep petroleum products moving to its shipper's terminals.

How Ni-Resist helps keep pumps 'on the line' in the toughest pipe-line and refinery jobs

Time and time again Ni-Resist* irons are specified for use in critical areas throughout the petroleum industry. The Byron Jackson pump pictured above, for example, uses Ni-Resist parts to help give it the dependability essential to pipe-line operations. In refineries Ni-Resist valve and pump parts, wear rings and sleeves give extra protection against corrosion, and insure long life where breakdowns are most costly.

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This extra protection against corrosion, erosion, heat and oxidation, and metal to metal abrasion are the main reasons why Ni-Resist is so often used for essential parts in refineries and pipe lines. Its moderate cost is also part of the picture. If you need longer and more dependable service from valves, reciprocal and centrifugal pumps, Ni-Resist irons may answer your problems.

The 76-page booklet, "Engineering Properties and Applications of Ni-Resist Irons" will give you full details on these exceptional high-nickel irons. Write in for your copy today. *Registered trademark

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NI-RESIST

NICKEL MAKES CASTINGS PERFORM BETTER LONGER

Men . . .

Texas. **Ed Lord** of Odessa, Texas, is to be the new superintendent of the Ambrose plant, transferring there from the Roberts Ranch plant near Odessa.

William C. Ruch has been appointed director of development research, Allied Chemical Corp., General Chemical Division. **Dr. Robert W. Mason** has been named director of laboratory research. **Charles D. Boyer, Jr.,** has become director, planning research. All three men have been with Allied for 14 years or more. The men, before these promotions, were assistant directors in their respective groups.

Ruch

Mason

Boyer

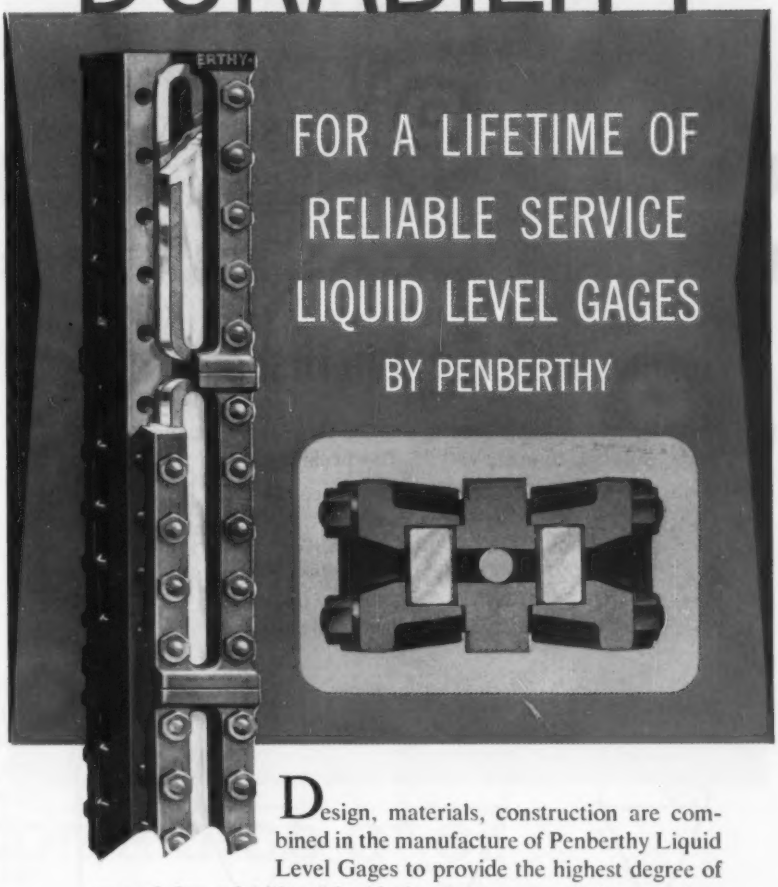
Dr. K. K. McMillin has been promoted to senior staff engineer, Central Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery. He is presently serving on a rotational assignment as head of the digital methods section.

W. D. Bartholomew has become design engineer at American Oil Co.'s Texas City refinery. Bartholomew joined American Oil Co. in 1953 as a junior construction and maintenance engineer in plant engineering.

Roger Swenson, Houston, has been elected assistant treasurer, Union Texas Natural Gas Corp. Swenson was formerly with Slick Oil Corp., Houston, for five years.

G. F. Bassler, Houston, has been promoted to manager of personnel relations, Continental Oil Co.'s international operations, with headquar-

DURABILITY



Design, materials, construction are combined in the manufacture of Penberthy Liquid Level Gages to provide the highest degree of rugged dependability. Liquid chambers are made in one piece from a solid bar of carbon or alloy steel and precision heat treated, machined and ground . . . for perfect, leak-tight alignment and rigidity. Covers, of temperature resistant steel, completely enclose sides and ends of glass and gasket . . . for blowout prevention. Pyrex glass is used exclusively . . . for its greater strength and resistance to shock and erosion. Even the gasket material is specially selected . . . for its high resiliency and ability to withstand excessive compression. In brief . . . For *lasting* accuracy in a liquid level gage, look to Penberthy.

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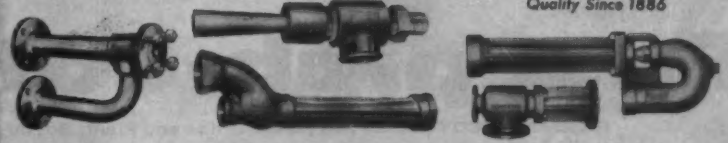

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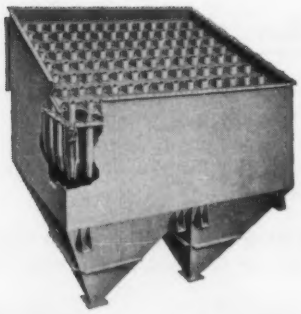

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Cyclo-trells have been engineered to provide the most economical solution to many gas cleaning problems.

Cyclo-trell's flexible design permits a wide combination of:

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- standard inlet and outlet locations
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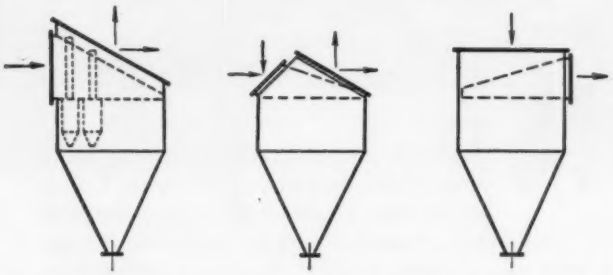


Most installations are engineered with a combination of these Cyclo-trell designs.

Whenever an installation requires a configuration different from the standard types shown, Research-Cottrell draws on its 49 years of gas cleaning experience in designing a custom-built unit. These custom units may be of the multiple tube or involute design, and are for power, cement, coal drying, chemical, petroleum, mining, quarrying, metals industry, or other applications.

Research-Cottrell engineers have also had wide experience in combining Cyclo-trell collectors with existing precipitators to increase collection efficiencies. This is particularly important when boilers are operating at increased loads and where higher collection efficiencies are required.

* Involute Cyclo-trell

Longer Tube Life for Low Maintenance Cost

Actual operating experience in the field has proven that Research-Cottrell tubes last longer.

This experience has led many users of dust collectors to specify Cyclo-trell tubes as replacements.

Two tube types are available. Standard chrome-vanadium tubes having a Brinell Hardness of 290-350, or, at a nominal price addition, for extremely abrasive conditions, tubes having a Brinell Hardness of 500-550 can be supplied. Outlet wear plates are included with the higher Brinell types.

Contact your nearest Research-Cottrell office for complete information on Research's line of mechanical collectors and electrostatic precipitators, or write our main office for Bulletin 300.

Research-Cottrell

RESEARCH-COTTRELL, INC., Main Office and Plant: Bound Brook, N. J.
Representatives in principal cities of U.S. and Canada.

RC228

MEMBER OF THE INDUSTRIAL GAS CLEANING INSTITUTE

Men . . .

ters in New York. Formerly assistant to the general manager of manufacturing, Panama operations, he will succeed **Sam W. Leonard,** who has been named controller, assistant treasurer and secretary of Petroquimica Argentina, S. A. (PASA), Buenos Aires, a Continental affiliate.

G. L. Graves along with **R. L. Lamm, E. J. Merkel, R. H. Schwartz** and **D. R. Silbernagel** have joined the Technical Division, Humble Oil & Refining Co.'s Baytown, Texas, refinery.

Kenneth W. Kramer has been promoted to project chemist, Technical Service Division, American Oil Co.'s Whiting, Ind., refinery. He started with the company in 1958.

Dr. Harold H. Zeiss, formerly of Monsanto Chemical Co.'s Research & Engineering Division, has been elected president and director, Monsanto Research S.A., Zurich, Switzerland. Dr. Zeiss has been on leave of absence from Monsanto since last year as a senior fellow of the National Science Foundation. He has been lecturing and serving as a guest professor at the universities of Munich and Heidelberg, West Germany.

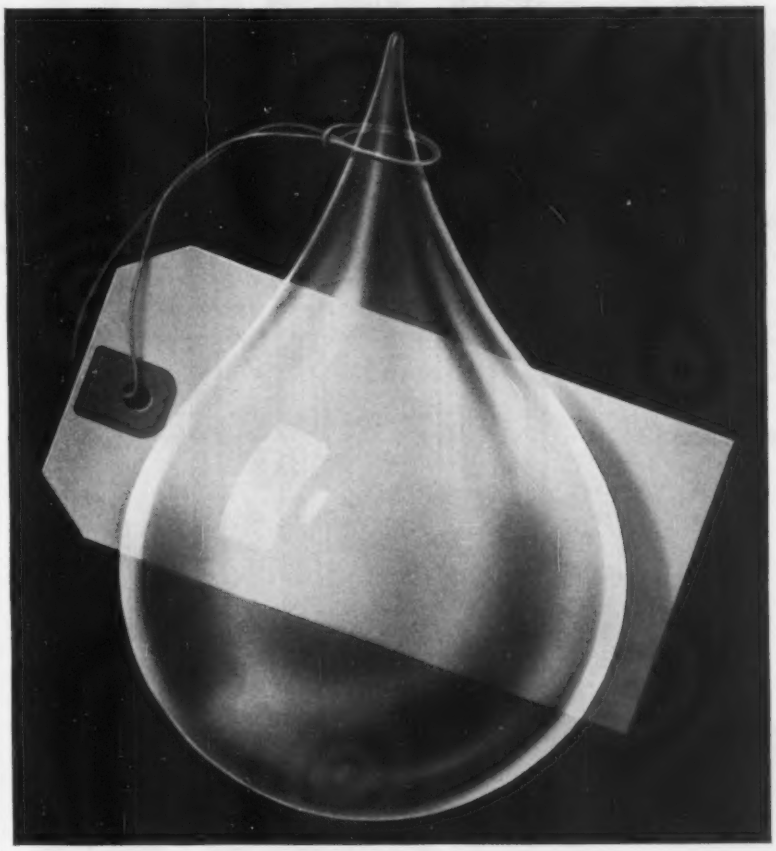
Dr. Robert J. O'Neill has joined Universal Oil Products Co. as an associate research coordinator. Dr. O'Neill was previously with Monsanto Chemical Co. as a research specialist.

William D. Morrison has joined Hooker Chemical Corp. as general manager, International Division. For the past five years, Morrison has been with FMC Corp. as manager, Central Development Department, general manager of International Chemical Operations of FMC International, and vice president and director of FMC International, Ltd.

A. K. May has been appointed general manager, Ethylene Oxide Chemicals Division, Houston Chemical Corp. May was formerly manager, Surfactants and Heavy Chemicals Department, General Aniline & Film Corp.

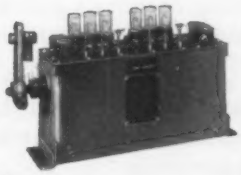
W. H. Barlow has been elected vice president, Chemical Product Development Division, The Ohio Oil Co.

What's the PRICE TAG



on a drop of oil?

The drop of oil that isn't there when it's needed can really cost you! That's why you should choose Manzel force-feed lubricators for your lubricating needs. They deliver just the right amount of oil to bearings, cylinders and packing... starting, stopping, speeding up and slowing down in synchronization with your machinery. They're unaffected by high steam, gas or air pressure. Whatever your lubrication needs, Manzel lubricators can save you money. For our catalog, write Manzel, 256 Babcock Street, Buffalo 10, New York. You'll solve all your lubricating problems if you...



ask the man from

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SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

For more data on advertised products, use cards, last page.

is the only way

There is no other way in which you can learn so much, so quickly about so many new developments than by visiting the fact-filled Exposition of Chemical Industries. To actually SEE and compare the new cost-saving products of over 500 manufacturers in one location will pay big dividends in new ideas that can be applied in your plant.

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28th EXPOSITION OF CHEMICAL INDUSTRIES

N. Y. Coliseum, Nov. 27—Dec. 1, 1961

MANAGEMENT: International Exposition Company, 480 Lexington Ave., N. Y. 17, N. Y.

Men . . .

Barlow was manager of research and planning, and a member of the board of directors since 1959. He joined Ohio in 1942 as a petroleum engineer. **Dr. R. H. Reitsema,** a senior planning associate, has been named manager, Chemical Product Development Division. Dr. Reitsema joined the company in 1957.

George M. Freeser, Jr., has been appointed plant manager, Baker & Adamson Works, Allied Chemical Corp.'s General Chemical Division. Freeser replaces **Ralph E. Bankert,** who has been a product manager at General's New York headquarters. Freeser, who has been with Allied for 37 years, was superintendent, Baker & Adamson Works, for the past 16 years.

Joseph J. Daniels has been elected to the board of directors, National Distillers and Chemical Corp. Daniels, senior partner of Baker & Daniels, Indianapolis law firm, is general counsel for Panhandle Eastern Pipe Line Co. He succeeds **Leslie T. Fournier,** who has died.

F. B. Ingram, New Orleans, has been elected a director of Murphy Corp. Ingram had been executive vice president of Ingram Oil and Refining Co. which was merged with Murphy.

Charles J. Billerbeck has been named project chemical engineer, Technical Service Division, American Oil Co.'s Whiting, Ind., refinery. He joined the company in 1955.

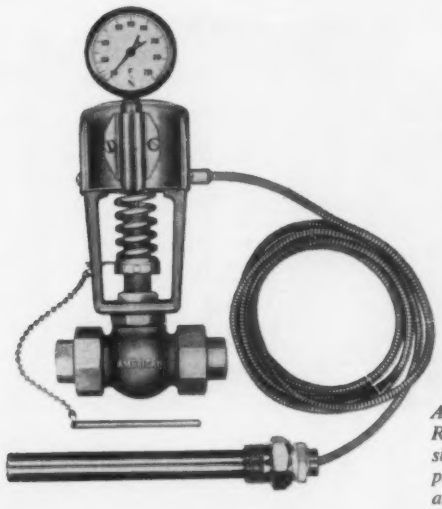
— Deaths —

Tommy Thompson, president of Petroleum Electric Power Association, died of a heart attack September 20 in Mobile, Ala. Thompson was with the Public Service Co. of Oklahoma.

Dr. Leonard W. Doolan, 54, manager of Tidewater Oil Co.'s Eastern Division, Lubricants Supply Department, died September 3 at his home in Scotch Plains, N.J. He had been with Tidewater for more than 25 years, having joined the Bayonne, N.J., refinery in 1935 as a development engineer.

immediate

AMERICAN TEMPERATURE REGULATORS begin corrective action with less than 1/10 degree change at the bulb



American Temperature Regulators are made in sizes ½" to 4". Temperature ranges as low as minus 15° F. to 50° F.—as high as 240° F. to 350° F.

response

You get fastest possible temperature response from these new regulators because the stem cannot bind and retard valve action.

The valve stem on American Temperature Regulators is sealed off by a friction-free bellows that makes practical a nonleaking packless valve. Also contributing to fast, stable action is the use of an extra-long preflexed adjusting spring. This spring permits a long range of temperature adjustment without disturbing valve sensitivity at normal levels.

There are other high-quality features in American Temperature Regulators: maximum use of stainless steel; standardized parts; the fewest possible components; and unitized assembly. In addition, compactness simplifies installation in "tight" locations.

Accurate temperature regulation and attention-free operation mean long-term economy. Your industrial supply distributor will gladly help you select the right American Temperature Regulators for your needs. Write for Bulletin 114A.

MANNING MAXWELL & MOORE M&M TRADE MARK

AMERICAN TEMPERATURE REGULATORS

A product of

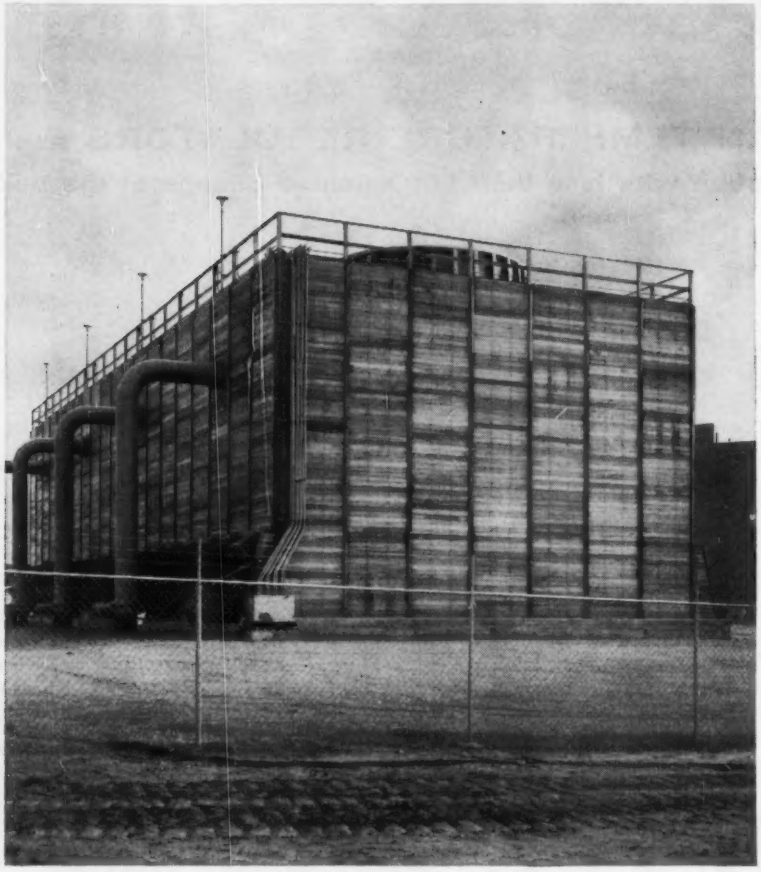
MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut

Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario
Latin America: Export Division, Chrysler Building, New York, N. Y.
Europe: Manning, Maxwell & Moore, S. A., Fribourg, Switzerland

For more data on advertised products, use cards, last page.

CORROSION COSTS CAN BE LOWERED



No matter how you figure it—in terms of replacement costs, treatment costs or higher production—Hagan can save you money by keeping cooling and service water systems at top efficiency. Complete treatment recommendations, based on experience with water problems in every kind of industry, are backed up by continuing service after treatment is started. Hagan's methods have achieved these results:

LOWER CHEMICAL COSTS: In most systems, treatment is more effective. This means that smaller amounts of chemicals can be used.

LOWER WATER COSTS: With more effective treatment, it is frequently possible to maintain higher solid concentrations in cooling water. This means less makeup water, and consequent savings in overall water costs.

BETTER RESULTS: In many plants, Hagan methods have reduced corrosion rates to 1 mil per year or less. At the same time, troublesome deposits were eliminated, increasing equipment efficiency, and overall chemical costs were lowered.

A letter or phone call will put Hagan Engineers to work on your particular water problem.

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CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO., HALL LABORATORIES, BRUNER CORP

New Books . . .

Safe Handling Data

Properties and Essential Information for Safe Handling and Use of Methyl Ethyl Ketone, Pamphlet SD-83, Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N. W., Washington 9, D. C., 30 cents.

Cost Bibliography

Sidney Katell, John H. Faber and Mary Jo Williams, *Bibliography of Investment and Operating Costs for Chemical and Petroleum Plants, January-December 1960,* United States Department of the Interior, Bureau of Mines, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C., 96 pages, 50 cents.

Chemical Research

A how-to-do-it book telling the hows and whys of research. E. Emmet Reid, *Invitation to Chemical Research,* Franklin Publishing Co., Inc., P. O. Box 65, Palisade, N. J., 384 pages, $10.60.

Book of Tables

Compactness is the outstanding characteristic of this book of tables (2⅝ × 5⅝ inches). *Trig, Log, Antilog, and Log of Trig Functions 6 Place Tables,* Ottenheimer Publishers, Inc., 4805 Nelson Ave., Baltimore 15, Md., 192 pages, $1.

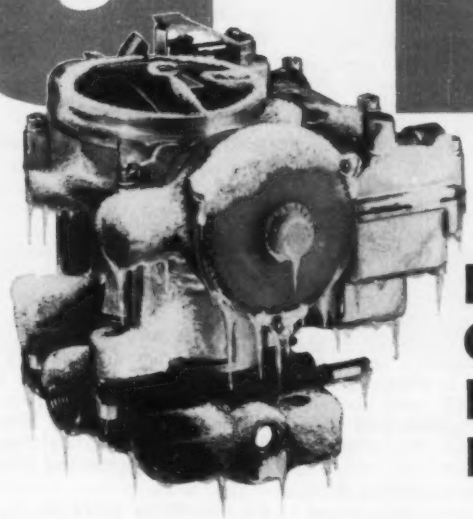
Paraffinic Hydrocarbons

Presents a method for calculating the contribution of component bonds of a molecule, for the total molecule, and for comparisons with other hydrocarbons. V. M. Tatevskii, V. A. Benderskii and S. S. Yarovoi, *Rules and Methods for Calculating the Physico-Chemical Properties of Paraffinic Hydrocarbons,* Pergamon Press, Ltd., Headington Hill Hall, Oxford, England, 128 pages, $5.50.

Safety Guide

Recommended Safe Practices and Procedures for Entering Tanks and Other Enclosed Spaces, Pamphlet SG-10, Manufacturing Chemists' Association, Inc., 1825 Connecticut Ave., N. W., Washington 9, D. C., eight pages, 30 cents.

S-41-K



FIGHTS CARBURETOR ICING ECONOMICALLY

Even under the most critical carburetor icing conditions, S-41-K at only 50 ppm stops stalling and rough idle economically.

At the same time—for no extra cost—S-41-K offers year-round protection against troublesome carburetor deposits.

WRITE TODAY for your copy of the S-41-K booklet reviewing extensive engine research, road testing and statistical data. Send your request to . . .

Central Soya
Chemurgy Division
1825 N. Laramie Ave., Chicago 39, Ill.

For more data on advertised products, use cards, last page.

Suppliers Notes...

LEEDS & NORTHRUP CO. has elected **Alexander H. Reynolds, Jr.,** vice president in charge of long-range planning. **Stephen Loidl, Jr.,** has become treasurer and controller, with direction of the Financial

Reynolds

Loidl

Department. Reynolds joined the firm in 1927; Loidl, about five years ago.

THOMPSON RAMO WOOLDRIDGE, INC., has appointed **Herbert J. Henderson** central region manager for TRW Computers Division. Henderson will headquarter in Chicago, and will handle computer sales in 13 central states and three Canadian provinces.

MISSION MANUFACTURING CO. has promoted **C. E. Van Loozen,** former western district manager, to industrial sales manager. **F. J. Herbert,** previously southeastern district production sales representative has become western district manager. **Harold Herren** replaces Herbert in the Southeast. **Melton Wright** has been appointed sales administrator.

TUBE TURNS PLASTICS, INC., has promoted **T. S. Bushnell** to sales manager, special products. **James L. Sheehy** has been named to succeed Bushnell as midwest district manager in Chicago and **Cliff M. Springmeier** to replace Sheehy as West Coast northern district manager in San Francisco.

GLOBE PACIFIC HOIST CO. has named **Paul E. Hughes** general manager. Globe Pacific Hoist is West Coast Division of Globe Hoist Co. Hughes replaces **John R. Queen,** executive head, West Coast plant since 1955, who has joined Shields, Harper & Co. as president.

U.S. INDUSTRIAL CHEMICALS CO. has named **John N. Murray** Minneapolis district sales manager. Murray joined U.S.I. in 1955. U.S.I. is a division of National Distillers and Chemical Corp.

ILG ELECTRIC VENTILATING CO. has made **Charles Phillips** branch manager, Baltimore office. Phillips, previously a sales engineer in Ilg's Philadelphia office, replaces **Ray Long.**

CONSOLIDATED SYSTEMS CORP. an associate company of Allis-Chalmers, Bell & Howell and Consolidated Electrodynamics, has elected **Philip S. Fogg** chairman of the board. He succeeds **William E. Roberts,** formerly executive vice president of Bell & Howell.

TRENT TUBE CO. has appointed **L. R. Miller** vice president, manufacturing. Miller joined Trent Tube in 1945 as chief metallurgist. He became chief engineer in 1956, and works manager in 1958.

ALLIED CHEMICAL CORP.'s General Chemical Division has named **Jack M. Blalock** manager of heavy chemical sales. Blalock, who has been with the division for 14 years, has been manager of market surveys for the past two years.

BENDIX CORP. has appointed four area sales chiefs for its eastern and western regions. Those named are: **Robert P. Fopeano,** western regional manager; **Cary W. Armstrong,** eastern regional manager; **George Karron,** New York district manager; and **George C. Peterson,** Washington, D. C., district manager.

PITTSBURGH-DES MOINES STEEL CO. has appointed **W. F. Hoffman** manager of industrial sales. He will coordinate and direct sales efforts in the petroleum, petrochemical and chemical industries. Hoffman, who joined the firm in 1948, has been manager, Dallas district sales office, for the past four years. Although his offices will be at the company's headquarters in Pittsburgh, his sales responsibilities will cover the entire country. He is a graduate of Cornell University.

Hoffman

KAISER STEEL CORP. has appointed **Richard C. King** Washington, D.C., representative. King, who has been with Kaiser Steel since 1955, has been working in company public relations.

HENRY PRATT CO. has made **Robert C. Beckwith** manager, manufacturing engineering. He was previously with L. B. Harris Management Consultants as an associate.

PENNSALT CHEMICALS CORP. has appointed **Dean E. McCrory** assistant district sales manager at Tacoma, Wash. McCrory, who joined Pennsalt in 1936, replaces **Ralph C. Schaeffer,** recently named district sales manager at Salt Lake City, Utah.

OWATONNA TOOL CO. has appointed **Thomas F. Devine** district manager for Southern Ohio, Eastern Kentucky and Southwest Virginia. Previously, Devine was with Commercial Solvents Corp. as a sales representative.

KOEHRING CO. has promoted **David W. Marchant** from president and general manager of Koehring-Waterous, Ltd., Brantford, Ont., to president and general manager of Koehring Division, Milwaukee, Wis. **Kensal R. Chandler** has

Marchant

Chandler

been named president and general manager of Koehring-Waterous. He was assistant vice president of sales, Koehring Division.

CHAIN BELT CO. has named **William T. Powell** manager, construction machinery section's Western Division. He succeeds **S. Y. Warner** who has become western regional manager, industrial section.

CONTINENTAL MANUFACTURING CO., Cincinnati, Ohio, manufacturer of chemical process valves, has opened a new office in Houston to provide regional sales management and technical sales assistance to company sales personnel in Louisiana-Texas, New Mexico-Arizona areas. **J. O. Sandridge** is office manager.

CATALYSTS AND CHEMICALS, INC., Louisville, Ky., has assigned **Jay Hager** and **Rolf Kogstad** to its Sales Department. Kogstad will be in foreign sales and Hager in domestic sales. Hager was with Seco Chemical Co., and Kogstad comes from Collier Carbon and Chemical Corp.

AIR REDUCTION SALES CO. has appointed **R. H. Merriman** manager, Gas Marketing Department. Merriman, who succeeds **G. L. Werly,** will direct nationwide sales and distribution of Airco industrial gases. He joined Airco in 1937.

HILLS-McCANNA CO. has formed a Canadian subsidiary, Hills-McCanna (Canada), Ltd., with headquarters in Toronto, Ont. **T. A. B. Clements,** formerly sales manager for Manning, Maxwell & Moore (Canada), Ltd., has been named general manager, Hills-McCanna (Canada).

GAR WOOD INDUSTRIES, INC., has made **William E. Van Horn** Hydraulic Division sales manager. Van Horn will make his headquarters in Wayne, Mich.

GEIGY CHEMICAL CORP. has elected **Charles A. Suter** president. Suter replaces **William F. Zipse,** president since 1943. Zipse has become chairman of the

Kerotest Keeps the PRESSURE ON for Quality

Before any Kerotest cast steel globe valve goes on stream, it's tested and approved in this final three-phase hydrostatic test. Here, with valve open and flanges blanked, the shell is subjected to maximum specified water pressure. The valve disc is then closed and the seat seal is checked hydrostatically and by air.

This testing stand adjacent to the production line is but one of the many quality control procedures employed at Kerotest to insure soundness of castings, seat seals and other operating parts. What's more, Kerotest's advanced design features bring you more precise flow control and regulation, reduce maintenance to a new low and assure longer valve life in all types of applications.

Kerotest Cast Steel Globe Valves

High quality Kerotest cast steel globe valves are available in primary service pressure ratings ranging from Series 150 to Series 1500. They are supplied in various combinations of body and trim material for all types of service in oil, gas, steam, water, chemical, petro-chemical, marine and industrial installations.

Send for your free copy of the new, informative Kerotest booklet. It's packed with working tables, dimensions, specifications and other helpful information.

KEROTEST
Quality Controlled Features

- Reinforced sections protect against unusual line strains, erosion and corrosion.
- Built for repacking under pressure in the full open position.
- Deep stuffing box for greater packing life and tighter seal.
- Threaded shoulder seating type seat rings replace without removing valve body from line.

There is a Kerotest Cast Steel Valve available for every class and condition of service.

KEROTEST MANUFACTURING COMPANY

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In Canada . . . Kerotest Cast Steel Valves are manufactured and distributed exclusively by Guelph Engineering Company, Guelph, Ontario, Canada

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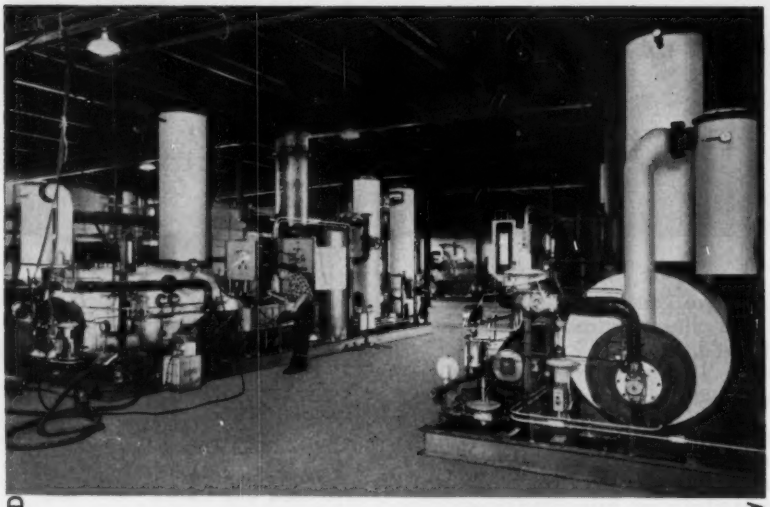
EVEN THE BIG ONES ARE FACTORY ASSEMBLED AND THOROUGHLY TESTED AT GAS ATMOSPHERES

The pair of 10,000 cfh high-purity nitrogen generators pictured below is undergoing complete factory testing prior to shipment to the customer. This is standard practice at Gas Atmospheres.

GENERATORS MUST EXCEED SPECIFICATIONS in production, gas purity, and dryness. This rigorous testing assures buyers of quick and easy start-up without job-site disorder, and it cuts servicing and maintenance to the bone.

GAS ATMOSPHERES ORIGINATED PACKAGED GAS GENERATION SYSTEMS by increasing the productivity of various components, consolidating operations, and designing the unit into as compact an area as possible. This means smaller generators today produce greater volume, and the entire unit can be factory assembled on a common base and shipped and installed as a complete unit.



Two compact 10,000 cfh high-purity packaged nitrogen generators on test floor at Gas Atmospheres Assembly Plant.

IF YOU USE GAS, EVEN IN SMALL AMOUNTS, it might pay you to produce your own with a modern gas generation system. It costs nothing to have your operation checked out by America's foremost designer and builder of packaged gas generation systems. Just call or write *Gas Atmospheres, Inc., 3855 West 150th Street, Cleveland 11, Ohio.*

gas Atmospheres, inc
equipment for producing industrial gases

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NERATORS

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Suppliers . . .

executive committee. Suter had completed 10 years with J. R. Geigy, S.A. in Switzerland prior to joining the United States firm. He has been executive vice president since 1950.

TAPECOAT CO. has appointed **J. Russell Wall** assistant general manager. Wall, previously in charge of Canadian operations for the company, joined Tapecoat in 1952 as a sales engineer in the Pittsburgh area. He will headquarter at Evanston, Ill. **Harold J. Picard** has been named manager in Canada replacing Wall.

TAYLOR FORGE & PIPE WORKS has transferred **R. M. Vilsack** to Chicago as manager of field sales, Flanges and Fittings Division. He was regional manager of sales, Eastern Division, New York City. **J. A. Lynch, Jr.,** formerly assistant to Vilsack, has been promoted to regional

Vilsack

Lynch

Kuckuck

Del Buono

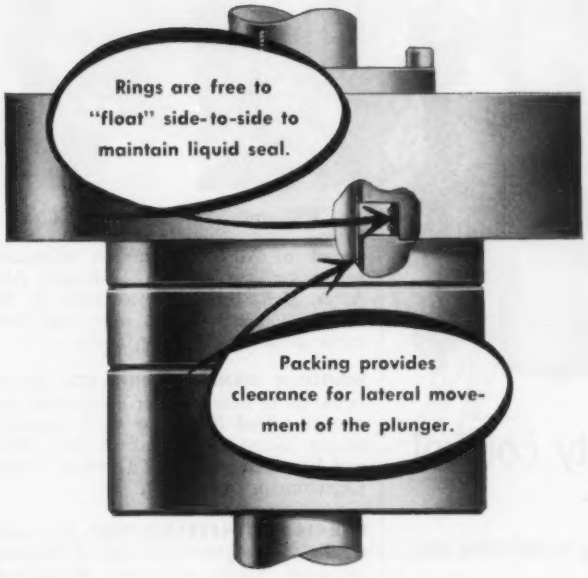
sales manager, Eastern Division. **F. C. Kuckuck,** who has been assistant general manager of sales, has been appointed assistant to the vice president in charge of sales. **A. J. Del Buono** has been named general manager, sales engineering.

AIR REDUCTION SALES CO. has named **G. L. Werly, Jr.,** general marketing manager. He will direct operations of Airco's equipment marketing, gas marketing and distributor marketing departments from the New York office. Werly has been with Airco since 1951 when he started as a sales trainee.

ALLIED CHEMICAL CORP.'s General Chemical Division has named six regional sales office managers and five assistant managers. New sales managers and their offices are: **Arthur H. Baker,** New York; **Albert B. Connelly,** Houston; **Harold E. Donaldson,** St. Louis; **William P. Doyle,**

THIS LIQUID-PUMP PACKING ACTUALLY FLOATS TO ELIMINATE COSTLY LEAKAGE PROBLEMS

Cook's special full-floating, self-adjusting packing boosts performance, reduces downtime of high-pressure plunger pumps


Rings are free to "float" side-to-side to maintain liquid seal.
Packing provides clearance for lateral movement of the plunger.

Plungers of all liquid pumps tend to "run out of true." As a result, conventional packings must make room for this lateral movement with a clearance around the plunger. Thus, a path is soon formed and excessive leakage occurs. This leakage can be reduced by adjustment but soon starts again.

To eliminate this annoying and expensive packing problem, Cook has designed a special liquid-pump packing which has proved itself in a number of varied field applications. This Cook packing actually *floats with the movement of the plunger*. It doesn't have to make room for the "run-out" of the plunger—it simply moves with it!

Cook packings are now successfully handling all types of liquids—oil, water, chemicals, brine, etc.—under many special operating conditions. These self-adjusting packings now make possible trouble-free performance without frequent adjustments. They are adaptable to all new or existing pump designs and become part of the permanent pump assembly. Ask a C. Lee Cook representative to give you the details about this special liquid-pump packing.

WRITE FOR MORE INFORMATION

If you want Cook engineers to review the special requirements of your specific liquid-pump packing application, just send the necessary details to C. Lee Cook Division, Dover Corporation, 950 South Eighth Street, Louisville 3, Kentucky. Or send for complete information about any of Cook's complete line of rings and packings.

COOK SEALS LIQUIDS AT EXTREME PRESSURES AND TEMPERATURES

C. Lee Cook has unique experience in the advancement of liquid-seal technology. Recently completed research and development contracts (one with a major airframe and missile manufacturer) have resulted in new concepts of seal design, materials compatibility, friction limitations and sealing efficiency. If yours is a special packing application, call in a Cook representative.

C. LEE COOK
DIVISION OF DOVER CORPORATION
Rings and Packings Since 1888

For more data on advertised products, use cards, last page.

Suppliers . . .

Buffalo, N.Y., **Edmund R. Lett,** Birmingham, Ala.; and **Wesley G. Webster,** Denver, Col. Assistant sales managers: **Lester I. Adams,** New York; **Joseph M. Byouk,** Chicago; **Stephen J. Muller,** Los Angeles; **Richard J. Regan,** Philadelphia; and **James E. Strader,** Chicago.

HAZARD WIRE ROPE DIVISION, American Chain & Cable Co., Inc., has appointed **Arthur C. Motl** district manager for oil industry sales. Motl will headquarter in Houston. He succeeds **Harry S. Frady,** who has retired.

ALLIED CHEMICAL INTERNATIONAL has named **Wallace A. Senten** manager of its Mexican branch. Senten came to Allied Chemical from Bridgeport Brass Co.

BELL & HOWELL CANADA, LTD., has elected **Robert H. Garretson** to the board of directors. Garretson is executive vice president of Bell & Howell Co., Chicago, and president of Consolidated Electrodynamics Corp., Bell & Howell subsidiary.

CHICAGO BRIDGE, LTD., Chicago Bridge & Iron Co.'s British subsidiary in London, has elected **Dean E. Stephan** managing director. Stephan succeeds **Cecil A. Wooten,** who is presently co-manager of Chicago Bridge et Provence, CB&I's French affiliate. Stephan joined the company in 1930.

JONES & LAUGHLIN SUPPLY DIVISION has appointed **H. B. Carruth, Jr.,** formerly assigned to the Houston store, salesman at Longview, Texas. **B. E. Irby,** salesman at Longview, has been assigned to Ruston, La. **J. B. Williams** has been transferred to Mexia, Texas as salesman-supervisor. He was at El Dorado, Ark. **A. A. Bell,** previously assigned to the Corpus Christi, Texas, store, has been made salesman at Luling, Texas.

Carruth

Irby

Williams

Bell

WHITLOCK MANUFACTURING CO., manufacturers of heat transfer equipment, has named **Alfred N. Major** chief engineer. Major joined Whitlock in July 1950, and has been manager, Thermal Design Department, since 1954.

FARRIS ENGINEERING CORP. has made **G. Frank Bright** southwestern regional manager. Bright was with Manning, Maxwell & Moore, Inc., for 10 years as product and marketing manager, Consolidated Valve Division. He will headquarter in Houston.

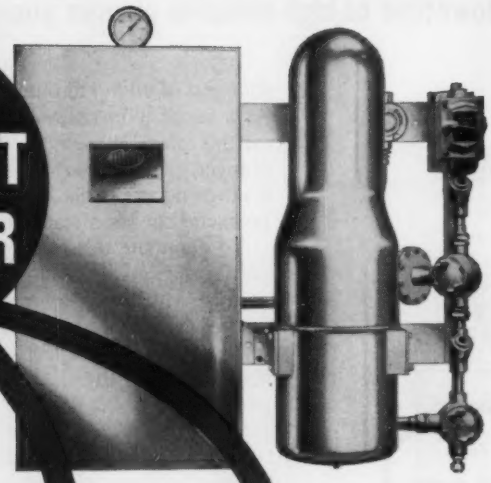
BORG & BECK DIVISION, Borg-Warner Corp., has elected **Harold Nutt** chairman and chief executive officer. Nutt, who joined Borg & Beck in 1930 as director of engineering, has been president and general manager since 1955.

ATLANTIC METAL HOSE CO. has named **Joseph A. Venti** assistant to the sales manager. Venti has been supervisor of customer services for eight months. Prior to joining Atlantic Metal Hose, he was with Flexonics Corp. for 13 years.

OAKITE PRODUCTS, INC., has assigned **Robert P. Jones,** New England Division manager since 1954, to the New York headquarters. Jones joined Oakite in

now on-stream

TOTCO END-POINT ANALYZER



optimum returns through quality control

Among companies now using one or more Analyzers for monitoring or controlling are:

The Atlantic Refining Company	Standard Oil Company of Calif.	Texas City Refining, Inc.
Gulf Oil Corporation	The Standard Oil Company of Ohio	Tidewater Oil Company
Mobil Oil Company	Sun Oil Company	Wilshire Oil Company of California
Richfield Oil Corporation	Texaco, Inc.	and many other leading firms.

Applications include quality control of reformer feed, gasoline and distillate components, and "special" products.

Permits closer control to end-point specifications and increased yield. Continuous analysis improves quality. Write for Bulletin 6000-11.

Totco also makes an Initial Boiling Point Analyzer. Write for Bulletin 1259-11.

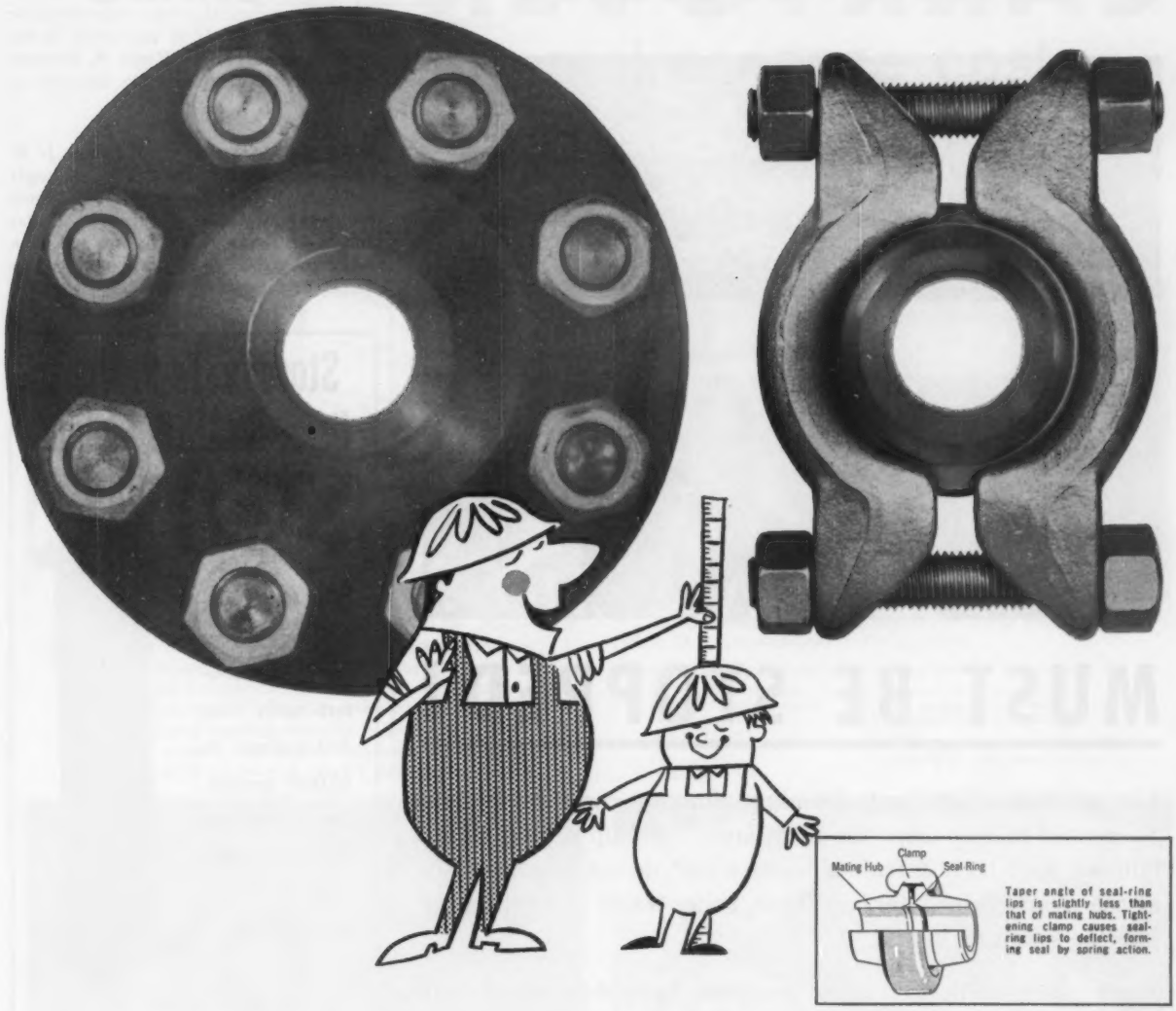
MANUFACTURERS OF PRECISION INSTRUMENTS SINCE 1929

TOTCO

TECHNICAL OIL TOOL CORPORATION
1057 North La Brea Avenue
Los Angeles 38, California • OLdfield 4-1763

Representatives:
Energy Control Co., Inc. — 5 Beekman Street, New York 38, New York • Energy Control Corporation — 3147 No. Broad St., Philadelphia 32, Pa. • EPCO Services — 888 East Northwest Highway, Mt. Prospect, Illinois • Melvin Fusfeld — Zeekant 95e, The Hague, Holland • Kirk Equipment Ltd. — 1460 Bishop St., Montreal, P.Q., Canada • The Mott Co. — 1719 McKinney St., Houston 1, Tex.

Grayloc Pipe Connections Save 1/3 the Space



Mating Hub
Clamp
Seal Ring
Taper angle of seal-ring lips is slightly less than that of mating hubs. Tightening clamp causes seal-ring lips to deflect, forming seal by spring action.

GRAYLOC® pipe connections are up to one-third smaller than flanged connections with comparable maximum pressure ratings. They save wasted space — cut unit weight and assembly time drastically.

An all steel assembly, GRAYLOC employs a pressure aided seal that can be assembled or disconnected in minutes. The heart of the assembly — the seal ring — is completely reusable.

Although GRAYLOC connections are manufactured in standard stock sizes from 1″ to 30″, special sizes for special applications are available on request. Corrosion resistant metals can be provided on short notice.

You can use GRAYLOC connections in your piping system. They'll save you maintenance and assembly time, space and money. To learn how, write for the new GRAYLOC catalog.

GRAYLOC SALES DIVISION

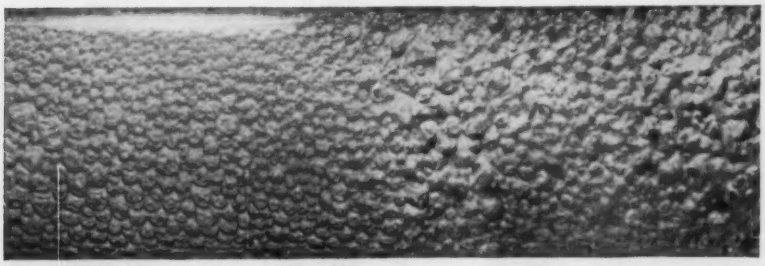
GRAY Tool Company

P. O. BOX 2291 • HOUSTON 1, TEXAS • Riverside 7-1240

6112

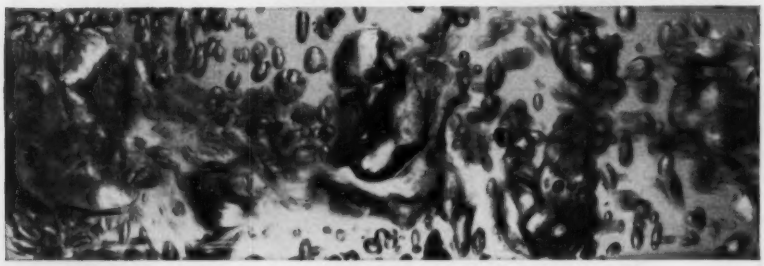
For more data on advertised products, use cards, last page.

CARRYOVER



Foam build-up in untreated boiler water

No foam in boiler water treated with Concentrol



MUST BE STOPPED!

Carryover of solids due to foaming is in most cases continuous. Suspended matter helps the foam layer build up so that steam bubbles, with their entrained boiler water, do not break quickly at the steam-water interface. Thus, boiler water is carried over into the steam mains.

Many plants with wet steam problems have determined that carryover must be stopped and have turned to the Bird-Archer Company for an economical solution. Bird-Archer research in stabilizing boiler water with high foam potential is backed by 60 years experience. The result is the development of a highly effective antifoam agent called CONCENTROL. Even when used in relatively small dosages Concentrol is effective in combining both resistance to hydrolysis or breakdown under boiler temperatures and pressures with ability to control foam.

Write for Bulletin on "Concentrol", and name of the Bird-Archer Service Engineer nearest you.

BA102

BIRD-ARCHER

WATER TREATING CONSULTANTS

The BIRD-ARCHER Company, 4337 N. American St., Phila. 40, Pa. / New York • Chicago

The BIRD-ARCHER CO. of California, 415 Brannan St., San Francisco • Offices in Canada and Mexico

Suppliers . . .

1949 as a technical service representative in Indianapolis. He is succeeded in his New England post by **Roger R. Heroux,** formerly representative in Springfield, Mass.

KILBY STEEL CO. has appointed **J. E. O'Brien** inside sales and office manager at Houston. **J. R. Lamp** has been named tubular sales representative for Dallas and West Texas. **R. D. Bartow** has been made tubular sales representative for Tulsa, Okla., and surrounding areas.

Storage Tank Vent Drier GUARDS Liquids against Moisture . .

This 40" desiccant-type drying column will protect tanks from 500 gallons to 50,000 gallons. The unit will dry vent air to a dew point of minus 100°F.

Write for Complete Details

W. A. Hammond Drierite Co.

120 Dayton Avenue, Xenia, Ohio

REFRACTORY HAYDITE

Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite. We sell direct to you.

CONSTRUCTION MATERIALS

CARTER-WATERS

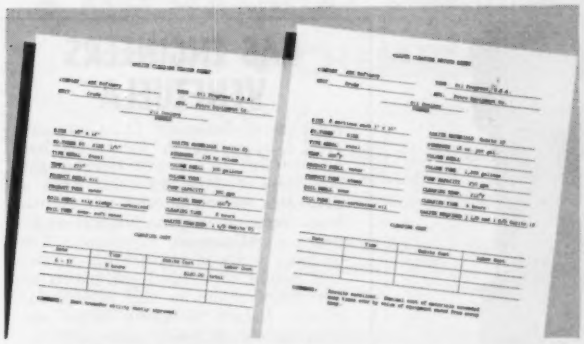
KANSAS CITY MISSOURI

2440 Pennway Phone GRand 1-2570

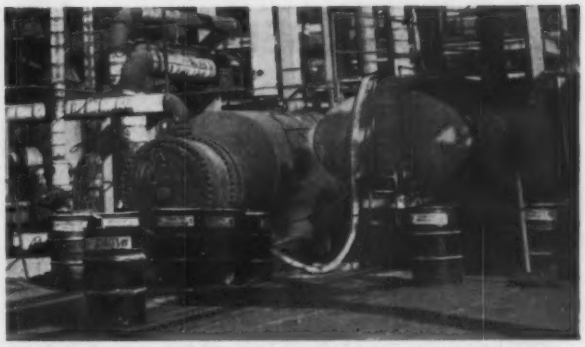
Oakite ECP* speeds turnarounds ...cuts maintenance costs

engineered cleaning program

*E.C.P. stands for Engineered Cleaning Program. Here's how it helps save money



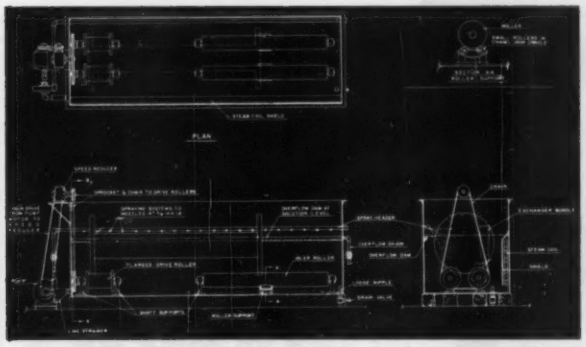
IT MAKES SPECIFIC RECOMMENDATIONS. An Oakite ECP spells out the whole course of cleaning action—from valve to tower. It estimates the material quantities needed and off-stream time expected for specific items of processing equipment and refinery maintenance. The world's finest laboratory facilities engaged in cleaning research cooperate in analyzing stubborn soils, recommend suitable cleaners, and implement the Oakite petroleum engineers' knowledge of refinery cleaning.



IT'S COMPREHENSIVE. If the equipment needs cleaning, an Oakite ECP accommodates it. For example:

Process Equipment Cleaning
- Bubble cap, cascade and perforated tray type towers
- Raschig ring towers
- Heat Exchangers
- Condensers
- Reboilers
- Preheaters

General Refinery Maintenance
- Storage tank cleaning
- Tank car and truck cleaning
- Reclamation of valves, fittings, pipe
- Drum washing
- Cleaning for safety and appearance



IT GIVES ENGINEERING DETAILS. You get engineering drawings of recommended set-ups for in-place cleaning, cleaning in tanks, etc. A fully staffed engineering department develops standard mechanized cleaning units with a wide variety of refinery uses. Among these important developments, the "Hurriclean" Steam-Detergent Gun removes caked-on soils from salvage parts too large for tank immersion, the Interior Tank Cleaning Unit expedites change-overs in cars and barges. The portable Hot-Spray Unit mechanizes cleaning in and around pump houses.

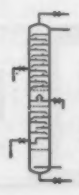
IT OFFERS HELPFUL BOOKLETS. Among the various factual and job-aiding data available from Oakite are these three booklets covering the cleaning jobs of major importance. Send for them without obligation. Ask also for more details on Oakite Engineered Cleaning Programs—or better still, ask your local Oakite man to develop one for you and and demonstrate its benefits. Oakite Products, Inc., 44C Rector Street, New York 6, N. Y.

OAKITE
SCIENCE
over 50 Est. 1909 years' in industrial cleaning

OAKITE ECP benefits you from the ground up . . .

at drilling site it speeds such salvage operations as paint stripping, rust removal, degreasing

it restores pipeline efficiency through chemical cleaning... it simplifies pump station housekeeping



It simplifies and speeds up column and tower maintenance through in-place chemical cleaning.

For more data on advertised products, use cards, last page.

WHY VENT DOLLARS TO THE ATMOSPHERE?

Use a QUIK-SERT to eliminate the loss

Why let profits escape into thin air when there's such a practical way to save them? You know that a safety valve can't always stop leakage. And many toxic, inflammable or odorous gases are hard to seal. That's why you need a Quik-Sert. This BS&B Rupture disc gives you absolute tight shutoff. Nested in its mounting under the safety valve, it protects the valve from corrosive action and, thus, cuts down valve maintenance.

The BS&B Quik-Sert is a completely trouble-free safety device. Teamed with a safety valve, it is a foolproof way to eliminate vapor loss and reduce valve maintenance.

For descriptive literature on BS&B Quik-Sert, write to Black, Sivalls & Bryson, Inc., 7500 East 12th St., Kansas City, Missouri.

QUIK-SERT

BS&B BLACK, SIVALLS & BRYSON

KANSAS CITY • OKLAHOMA CITY • TULSA • EDMONTON • THE HAGUE

CONSTRUCTION
MANAGERS, ENGINEERS, ESTIMATORS

For
International Engineering Construction Firm

Applicants should have minimum of 5 years direct labor experience in refinery & chemical plant construction. Send resume to Box PR 1413, 125 W 41 St., N. Y. 36, N. Y.

GAS ENGINEERS VENEZUELA

Affiliate of Standard Oil Company (N.J.) operating in Venezuela has opportunity for experienced gas engineers. Candidates must have a degree in petroleum and gas, petroleum refining, or mechanical engineering. Minimum experience five or more years in engineering studies and design of natural gas plants or petroleum refineries and related facilities. Salary including bonus approximately $15,000; also liberal employee benefits and annual home vacations with travel expenses. Send detailed resume including personal data and work experience. All replies held confidential.

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Dept. N—Radio City Station
New York 19, New York

Computation Programming Refinery Economics

Our Refinery Technology Division needs men qualified to:

1. **Conduct studies of refinery economics using modern computing and mathematical methods, and**
2. **Develop computer programs (IBM 1620, 7090) in support of refining economics, fuel blending, and statistical analysis of fuel performance data.**

These professional positions in a technical-consulting activity offer and require a high level of individual responsibility. Projects vary widely and contribute directly to sales effort. Located in a suburb of Detroit, the division supports field-technical personnel covering U. S., Canada, Mexico and Export. Send resume to:

Personnel Manager
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1600 W. Eight Mile Road
Ferndale 20, Michigan

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Classified Ads
Don't Cost
They Pay

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RATES: **Regular Classified** (undisplayed) set in this type: 20 cents per word. Minimum charge, $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads**, set in suitably larger type with ruled border $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy dead line 25th of month preceding date of issue. Send copy and checks to: Classified Advertising, Hydrocarbon Processing & Petroleum Refiner, P. O. Box 2608, Houston, Texas.

HELP WANTED **HELP WANTED**

• MECHANICAL ENGINEER
• CHEMICAL ENGINEER

Positions now available on expanding staff of independent oil refining company in Upper Midwest area.

Graduate MECHANICAL ENGINEER with two to five years experience in petroleum refinery or related engineering. Will be responsible for mechanical design and cost estimate of refinery processing equipment in Engineering department.

Graduate CHEMICAL ENGINEER with two to five years petroleum refining or petrochemical experience. Will do process studies and other technical service for operating units, plus varied staff work in Technical Service department.

These engineers will work closely with operation of a modern, integrated refinery which includes crude distillation, catalytic cracking, polymerization, coking, hydrodesulfurization, catalytic reforming, alkylation and utilities.

Furnish complete resume of experience and education, including salary requirements.

GREAT NORTHERN OIL COMPANY

Attn: C. L. DRETZKE

P. O. Box 3596
ST. PAUL 1, MINNESOTA

■ Young Chemical Engineer with two to four years refinery or petro chemical design experience. Salary open with excellent fringe benefits. Long established engineering and manufacturing firm. Write Box 361-R.

Independent Integrated Oil Company located in Southern California has openings for

Chemical Engineers

with experience ranging from 2 to 12 years. Outstanding opportunity for individual growth. Qualifications emphasize new project planning, refinery and petrochemical plant improvement or revision. Background in operations, design and technical service highly desirable. Please forward resume including salary requirements.

Inquiries held confidential.
Box 363-R, PETROLEUM REFINER,
P. O. Box 2608, Houston, Texas

TECHNICAL SALES REPRESENTATIVE

Outstanding opportunity for young aggressive Chemical Engineer in our progressive company.

We are interested in you if you:

—Have Chemical Engineering degree and two to ten years experience in petroleum refining.

—Prefer hard work where your efforts are rewarded.

—Like working with people and a minimum of supervision.

—Don't mind traveling.

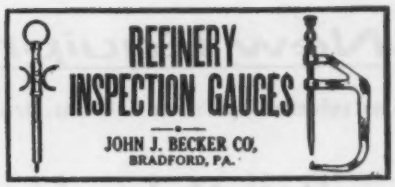
Send resume and photograph to:

R. J. Phillips, President
HOWE-BAKER ENGINEERS, INC.
Tyler, Texas **Phone LYric 3-6411**

POSITIONS WANTED

Representative Available. ARGENTINA, registered engineer, U.S. Citizen w/offices Buenos Aires, wants representation Engineering Construction Co. and suppliers of equipment. Available for interview during October in the U.S., PETROLEUM REFINER, P. O. Box 2608, Houston, Texas.

■ Chemical Engineer seventeen years intensive, broad background in Budget Administration, Economic Evaluations, Cost Analysis, Establishing Accounting Procedures, Manpower and Efficiency Studies, Operations, Technical Supervision, and Petroleum Refining. BB 360-R.



WANTED

Manuscripts Wanted

Have you written a book you would like to have published? Do you have an idea or an outline that you would like to talk over with a publisher? Gulf Publishing Company, publishers of World Oil, Hydrocarbon Processing & Petroleum Refiner and Pipe Line Industry magazines, and numerous technical books, is actively seeking trade and technical manuscripts for publication by its rapidly expanding Book Division. For further information write to Manager, Book Publishing, Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas.

ENGINEERS

Immediate openings for qualified applicants familiar with chemical cleaning or process equipment or municipal/industrial water and waste treatment. Specific opportunities for:

SERVICE & SALES ENGINEERS

Degree in chemical or mechanical engineering. Prefer power-plant or refinery experience in high-pressure steam generation; petroleum, chemical or water distribution; refinery processing equipment.

PRODUCT - SALES ENGINEERS

Degree required, preferably in engineering. Training or experience in chemistry, bio-chemistry or bacteriology acceptable. Background in waste treatment desirable.

Management recognition of initiative and ingenuity, unlimited opportunities for advancement. Group life insurance plus extensive major medical coverage. Unique retirement benefits.

Applicant must be willing to relocate and travel. Openings available nationwide. Individual preference for area assignments, if possible. Diversification of work assures full utilization of talent.

Mail resume to:
PERSONNEL MANAGER
DOW INDUSTRIAL SERVICE
DIVISION OF
THE DOW CHEMICAL COMPANY
20575 Center Ridge Road
Cleveland 16, Ohio

New Equipment & Literature...

as selected by Frank L. Evans, Jr., Mechanical Engineering Editor

Ball Valve Has Ball Sealed in Teflon Capsule

Major design feature of the new "Con-O-Sphere" ball valve is a "sealing capsule" of conical-shaped Teflon molded around the ball that controls the on-off action of the valve. The one-piece conical sealing capsule and spherical metal ball are the basis for the name, "Con-O-Sphere."

"The ability to market this valve with the ball, its handle stem and its sealing surfaces molded as one unit, enables us to offer maximum economy and minimum maintenance to users who must control the flow of gases, liquids and slurries," a company official said.

The valve has seven parts: the sealing capsule with its integral handle stem, the valve body, handle, Teflon stem seal (a small washer), a screw-in base plate, lock nut and set screw.

If extreme usage requires rebuilding the valve, the entire operation may be done in the line in approximately three minutes. Removal of the base plate and handle allows the sealing capsule to drop out of the body. A simple replacement of the capsule and a new stem seal completely rebuilds the valve. W-K-M Div., ACF Industries, Inc.

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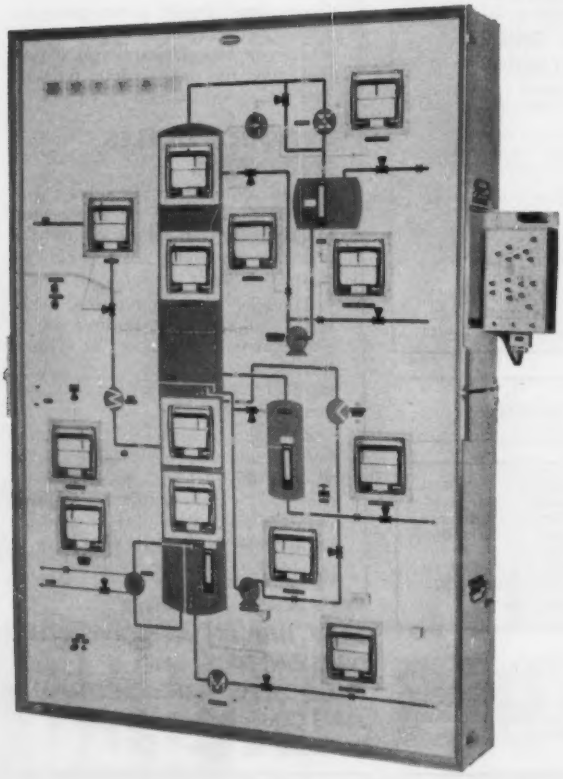

Fractionation Column Trainer Teaches Operators

A new training device called a fractionation column trainer is a full-scale unit that both looks and behaves like panels used to control fractionation columns. During the lecture phase of training, the instructor uses the trainer much as he might use installed instrumentation in an actual visit to the control room of a plant. Then, with a remote control console, he causes instruments on the trainer to simulate realistic changes in operating conditions . . . such as might occur during start-up or shutdown . . . or with changes in feed, or loss of pressure. The trainee must then take the necessary actions on the trainer to control or correct the operation. If he makes a mistake, alarms automatically go off as in the control room. Carmody Corp.

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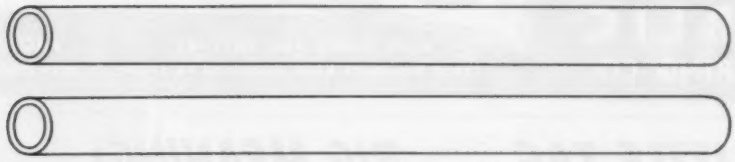
What's so different about stainless tubing?



What's so different about stainless tubing? Take two stainless tubes made by different manufacturers to the same specification. Put them in a heat exchanger. In service, they may react differently.

One tube successfully resists corrosion, the other doesn't. One holds up under pressure at operating temperature, the other fails. Why?

Basically, the difference in stainless tubing starts with who makes it.

One manufacturer maintains quality controls from melting of steel to finished tube. Another may not. One tube maker will carefully match stainless grades and properties to be sure the tube is *Job-Matched* to the user's specific requirements. Another won't. The differences go on and on.

The surest way to know how the differences in stainless tubing will benefit you is to know the manufacturer and what he can do. Then, specify his product by name when you order direct or through your Steel Service Center. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-1039S

Seamless and welded tubular products, solid extrusions, rolled rings, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

For more data on advertised products, use cards, last page.

HIGH QUALITY at LOW COST!

4 of the 20 available models

NEW . . . INSTRU-NEEDLE VALVES

Republic Instru-Needle Valves are better, and cost no more. They give unexcelled service in instrumentation, gage shut-off, test panels, and other small-line circuitry. Economical to install and maintain. Standard units have 10 different porting combinations — inline and angle, with internal and external pipe, 37° flared, and flareless tube. All are standard in regular and panel-mounting types.

Bodies are forged, either brass or stainless steel. Working pressures: brass, 3000 psi; stainless steel, 5000 psi. For complete information, ask for Bul. 959.

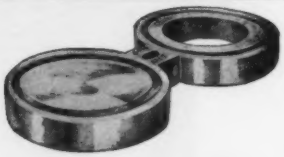
Stocking Distributors Coast to Coast 317

REPUBLIC MANUFACTURING CO.

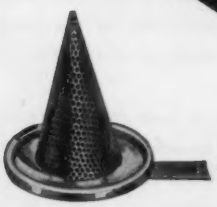
MAIN OFFICE AND FACTORY
15655 Brookpark Road, Cleveland 35, Ohio

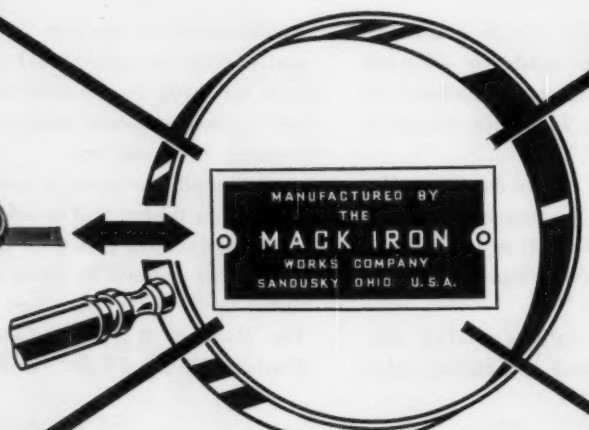
PACIFIC SALES DIVISION
15844 Strathern St., Van Nuys, Calif.

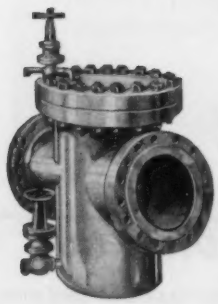
LITTLE TAG . . . BIG MEANING!



Not a mere name plate, this little metal tag on a piece of equipment is unreserved assurance of quality workmanship and dependability of service . . . *priceless characteristics not solely measured in dollars and cents.*







MAC-IRON CATALOG B-1

Although you'll find our full line Catalog B-1 in the current REFINERY CATALOG wouldn't you like more copies for distribution among your important engineering personnel?

Your request will bring all the copies you need.
WRITE TODAY . . .

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Stock and custom made items for many engineered applications which involve pumping of fluid materials and operational liquids.

BLINDS • SPACER RINGS • STRAINERS • SPECTACLE FLANGES

New Equipment . . .

20-Page Ethylene Booklet Gives Physical Properties

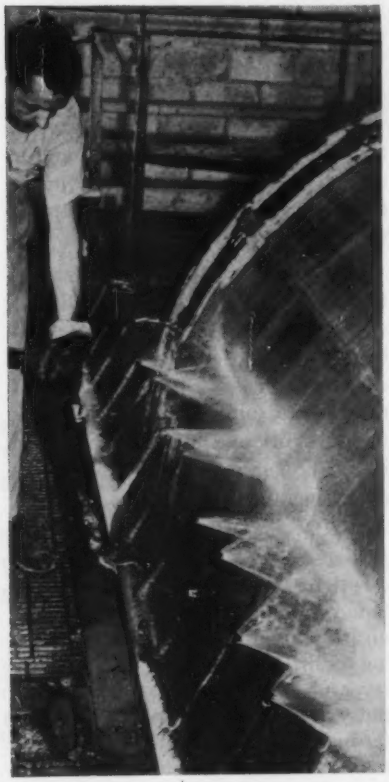
A new 20-page booklet on ethylene has been especially designed for developmental chemists and engineers using ethylene.

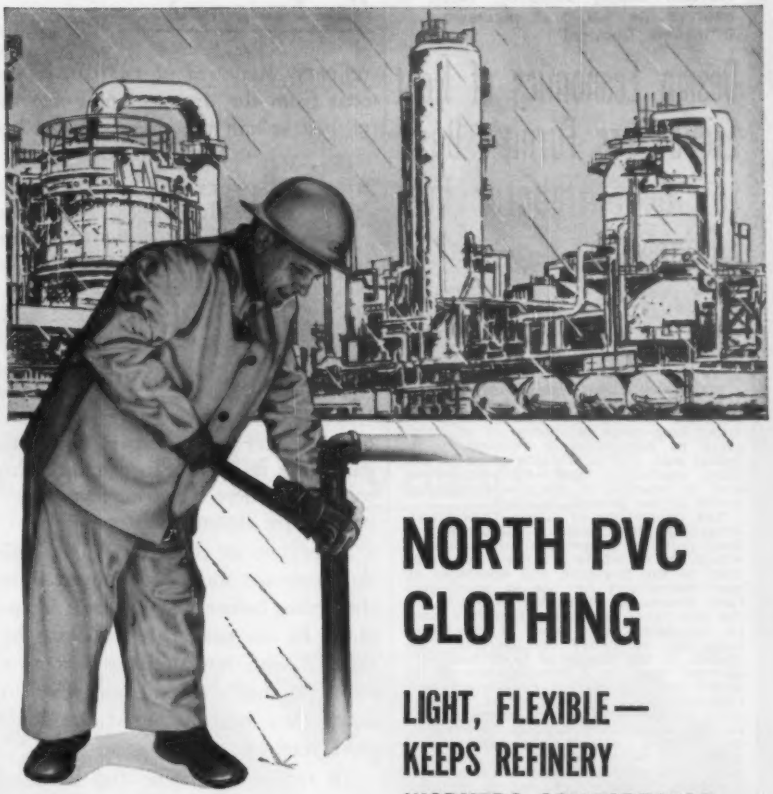
The booklet covers all major chemical reactions of the ethylene molecule and gives extensive bibliographical references for further investigation of reactions involving ethylene's double bond. In addition, physical properties of ethylene are given in both tabular and graphic forms to provide maximum convenience for readers. A table of thermodynamic properties of liquid and saturated ethylene vapor is also included. U.S. Industrial Chemicals Co.

Circle E3 on green card, last page

Jet Cleaner Cuts Downtime On Vacuum Filter Drums

A unique hydraulic jet cleaning system has enabled The Atlantic Refining Co. to reduce downtime of vacuum filter drums in the waste water treatment plant of its Philadelphia





NORTH PVC CLOTHING

LIGHT, FLEXIBLE— KEEPS REFINERY WORKERS COMFORTABLE

When clouds gather, and rain or snow falls, outdoor refinery workers don North PVC Wet-Weather Clothing by Jomac.

They stay dry because the shielded and electronically welded seams won't pull apart, the welded PVC buttons won't pull off, and the material is absolutely waterproof. They stay safe because North PVC clothing resists most chemicals, oils and greases, is safety yellow for maximum visibility. They stay comfortable because set-in sleeve design and generous cut provide complete freedom of movement.

Insist on North PVC gloves for maximum hand protection. They offer better fit, greater dexterity, more comfort, and superior safety in handling most chemicals, oils and greases.

WRITE TODAY FOR A FOLDER DESCRIBING THESE PROTECTIVE JOMAC PRODUCTS

JOMAC

Jomac Inc., Dept. M
Philadelphia 38, Pa.

In Canada: James North Canada Company Ltd., Simcoe, Ont.
"JOMAC Sells Quality . . . and Quality Sells JOMAC!"

For more data on advertised products, use cards, last page.

. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I.Q."* of engineers . . . (*"Income Quotient")

Design Economics of Heat Exchangers Furnish Basis for Heat Transfer Cost Engineering

The application of cost engineering practices in the accurate evaluation of capital equipment in the process industries is rapidly becoming more and more vital to the management of process companies, as margins of profit grow narrower.

Management now depends increasingly, therefore, on modern cost-engineering practices to evaluate realistically the true, long-range economy of a given piece of equipment in relation to its initial cost, cost of installation, maintenance, operation, labor, replacement — and in relation to the productivity or profit of the process involved.

The importance of efficient, practical, long-range forecasting is increasingly a focal point in the process industries as a whole, but no where is it more important than in the purchase and operation of heat exchangers for use in continuous flow processes, where the operation of the unit never ceases, and therefore must be calculated on a basis of maximum longevity, efficiency and service. Included in the design of each heat exchanger must be a consideration of its initial cost, its cost of installation (including piping, fittings, valves, flanges, etc.), its operation and maintenance (including corrosion-protection, mechanical maintenance, cleaning, re-tubing, replacement parts) — and the factor of labor costs attendant to the installation, operation, maintenance and/or replacement of the unit.

In each case, however, the basic factors must be considered and determined: capital, overhead, maintenance and unit process costs.

The Cost Engineer, therefore, must be committed to continual study, re-examination and revaluation of every area which contributes to the practice of chemical engineering, for it is from his fundamental and technical knowledge of the process involved that his eventual forecasts for productivity, efficiency and longevity must ultimately spring.

Considerable thought has been given to the "ideal" background or qualifications for the Cost Engineer. Certainly his primary requisite must be a thorough knowledge of chemical engineering, including, in the heat transfer field, an equally intimate grasp of the thermal and metallurgical engineering so vital to an understanding of heat exchanger design economics.

Secondly, he should have had practical experience in the production phases of the chemical business. Thirdly, he will be better equipped to understand the complexities of the "business" side of such evaluations, if he has had education and/or experience in a certain amount of business administration.

Clear, concise, understandable communications is another factor of great importance to the ultimate success of the Cost Engineer, for he must transmit his findings, make his recommendations and defend his decisions to a number of widely varied types of people, some with technical background and others with little or no technical knowledge.

The Cost Engineer must be tireless on detail, inquisitive at each point, yet tactful in his demands on subordinates and associates. Above all, although cost engineering presents a real challenge to his analytical mind, he must serve his purpose with genuine humility, cognizant of the amount he has yet to learn.

In short, he should have a proclivity towards the functions of management, for that is where he might very well be headed.

FOOTNOTE: For more detailed information on this subject, write for your free copy of Booklet E-3, "Cost Engineering," to WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and for assistance on heat transfer cost engineering, please suggest our services — whether or not there's a heat exchanger in your company's future!

New Equipment . . .

refinery. Removal of residual precoat from the drums is now accomplished in half the time required before.

Atlantic processes 80 to 100 tons of floculation sludge per day in the waste water treatment plant. Filtrate from the sludge is returned to the plant for further treatment.

Four large vacuum filter drums, each 10 feet in diameter and 18 feet long, are used to pull the filtrate from the sludge. Knives, extending the length of the drums, continuously cut off the filter cake. Conveyor belts carry the filter cake to an incinerator-boiler where it is used in generating 150-psi steam.

After two or three days' use, residual pre-coat must be removed from the drums before new pre-coat is applied. In the past, this was done by sluicing with low pressure water—a relatively inefficient method. Two to four hours were required for complete removal.

To reduce downtime and increase plant capacity, Atlantic engineers designed a system of manifold nozzles that force hot water under high pressure against the pre-coat to remove it from the drum. With this method pre-coat is removed and screen is cleaned in one to two hours.

Only two valves, water and steam, need to be turned to start the unit. After that, no further attention is required. Since the hydraulic jet unit has no moving parts, maintenance is negligible. Sellers Injector Corp.

Circle E4 on green card, last page

Epoxy Adhesive Bonds Mixer Plate to Crude Tank

Over six months ago adhesive bonding was used for the first time to attach mixer support plates to an in-service crude oil feed tank at the Shell Oil Co., Martinez, Calif. To date, the steel plates are still firmly bonded to the tank despite a continual load of 1,250 pounds.

Use of a high-strength epoxy adhesive restored the tank to service in less than one day. To weld the plates, the tank would have had to be drained and purged, a process requiring at least six days downtime at an approximate cost of $2,500.

The plate-anchoring problem developed when a mixer had to be added without delay to the 5-million-gallon tank. One end of the mixer was to be supported by a flange on the manhole cover—the other end had to be supported from the tank wall firmly enough to prevent mixer movement. A ground support was unsuitable because it could cause excessive propeller shaft deflection with subsequent leakage, overheated packings and shaft wear.

Two flat carbon steel plates (6 x 6 x ½-inch.) were to be attached to the tank about 8 feet from ground level. Steel J-bars would run from the eye holes in the plates to the mixer frame, with the slack taken up by turnbuckles.

On the basis of field and laboratory tests, Epon Adhesive 901/B-1 was selected to bond the plates. It bonds steel-to-steel with a tensile strength over 2,800 psi. It is resistant to moisture, sunlight, climatic changes and most organic liquids. In addition, it can be cured overnight at normal air temperatures.

The mating metal surfaces were prepared for bonding by sandblasting to bright metal. The gray paste and liquid hardener were mixed together until the mixture turned red, indicating complete blending. A 1/16-inch layer of adhesive was spread with a putty knife onto the plates and the tank. The plates then were pressed against the tank and a fillet was formed around the edges. They were supported with jury-rigged blocks until the adhesive had set. The following day, the adhesive bond was

...A SIMPLE RULE-OF-THUMB THAT LETS YOU REDUCE PACKINGS INVENTORY ...AND STILL HANDLE 9 OUT OF 10 VALVE AND PUMP PACKING JOBS!

FOR VALVES, J-M THERMO-CORE® (black) offers excellent heat resistance, maximum sealing under least compression, and adapts readily to equipment variations. For general use, Style No. 397 is recommended. This style consists of Inconel-reinforced asbestos yarns . . . braided over a soft center core of graphite and 100% white asbestos.

FOR PUMPS, J-M CHEMPAC® (white) combines the excellent sealing and heat-resistant qualities of asbestos with Teflon's immunity to almost all chemical and solvent action. Chempac Style No. 2009 is recommended to give you long, efficient and economical service on the majority of your pump, expansion joint and agitator applications.

For special conditions – or for any other mechanical packings application you can name–Johns-Manville produces the industry's most complete range of packing styles. These are described in J-M's new 64-page Mechanical Packings Book. It is designed to help you select the packing best suited to each particular requirement. For a free copy of PK-131A, write to Johns-Manville, Box 359, New York 16, N. Y. In Canada, address Port Credit, Ontario. Cable address: Johnmanvil.

JOHNS-MANVILLE JM

For more data on advertised products, use cards, last page.

Sealing Corrosives?

Teflon* Gaskets and "O" Rings Definitely Reduce Costs

...last for the life of the connection even in services such as concentrated acids, alkalis or solvents (except molten alkali metals).

...permit easy joint breaking without tearing or pulling—eliminate replacement cost and lost maintenance time for refinishing flange surfaces.

...can be used again and again—assure decided savings where joints must be frequently broken for cleaning and inspection.

Reduce *your* corrosive sealing costs with John Crane Teflon Gaskets, "O" Rings and Back-Up Rings. They are available in a full range of types and sizes, envelope or solid, also specials to specification. Request Catalog P-327 for complete facts.

Crane Packing Co., 6420 Oakton St., Morton Grove, Ill. (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

**DuPont Trademark*

John Crane — MECHANICAL PACKINGS — SHAFT SEALS — TEFLON PRODUCTS — LAPPING MACHINES — THREAD COMPOUNDS

CRANE PACKING COMPANY

New Equipment . . .

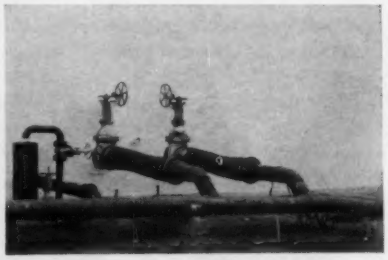
strong enough to take the full mixer load. Adhesive Dept., Shell Chemical Co.

Circle E5 on green card, last page

Hose Solves Storage Tank Settling Problem

Installation of new petroleum storage tanks poses a problem . . . how to relieve strain and prevent damage and costly repairs in the rigid pipe system connected to storage tanks caused by settling after installation. Solution: a flexible connector.

To compensate for the settling, hose engineers designed a connector system utilizing 8-foot overall lengths of 12-inch ID Flexjoint hose for main product lines, similar lengths of 8-



inch ID for blending lines, and 6-inch ID in water reclaim lines connecting to fixed-roof type tanks.

Reinforcement is accomplished by multiple plies of high tensile fabric and helical spirals of spring steel wire for maximum strength and optimum flexibility. Specially compounded synthetic tube is unaffected by gasoline, oil, or aromatic fuels. A tough neoprene cover provides resistance to petroleum products, sunlight, weathering and flame.

Built-in nipples, machined from seamless, standard weight steel pipe, are securely vulcanized into hose by the "Durabond" process, insuring maximum adhesion and preventing leakage at fittings. Steel flanges have standard 150-pound drilling and are welded to nipples except where lap-joint flanges are specified. Hewitt-Robins.

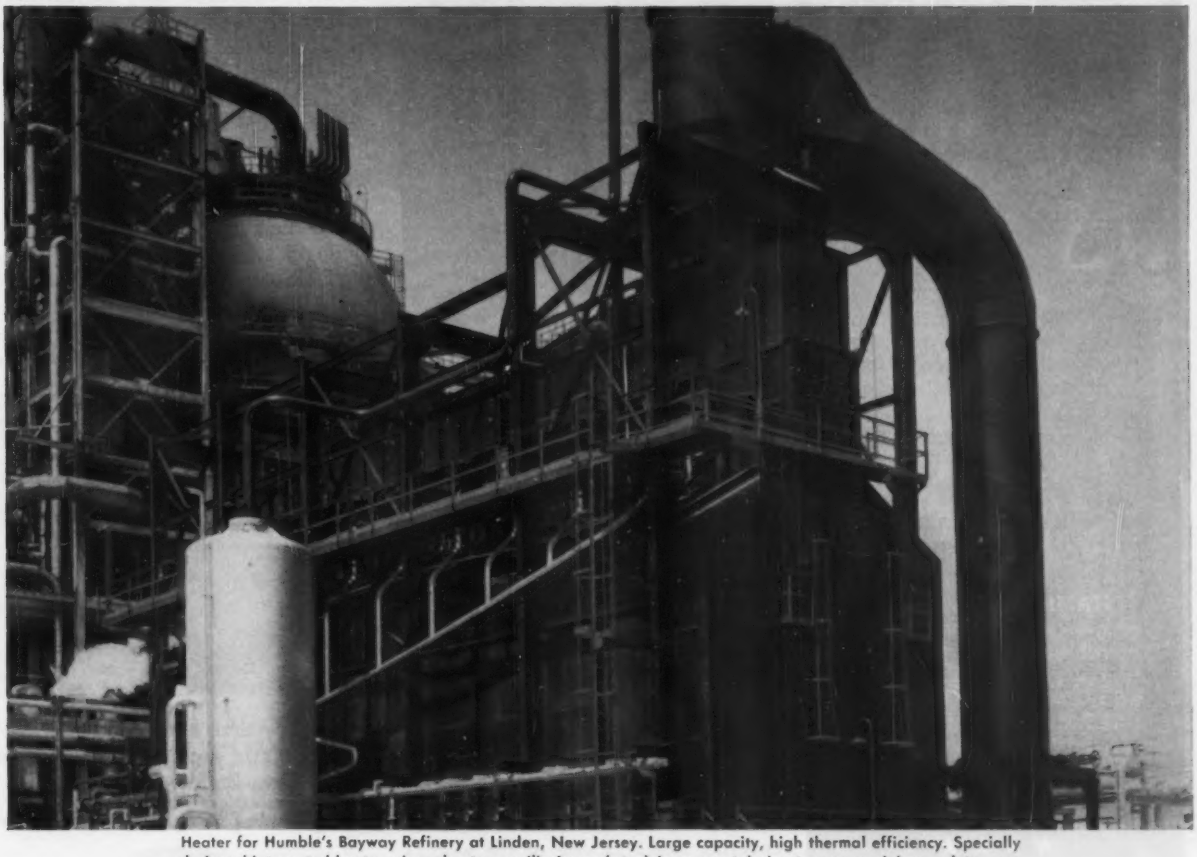
Circle E6 on green card, last page

Electric De-Hazer Treats And Cleans Furnace Oils

A new, compact electric de-hazer designed for bulk plant use in treating furnace oils to a clear, bright, haze-free product, eliminates costly

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY



Heater for Humble's Bayway Refinery at Linden, New Jersey. Large capacity, high thermal efficiency. Specially designed integrated heater, air preheater, auxiliaries and stack in compact design to occupy minimum plot space.

Lummus Oil Heater for Humble's Bayway Refinery meets three tough design requirements

LARGE CAPACITY, HIGH EFFICIENCY, LONG RUNS

Humble Bayway knew exactly what they wanted in a replacement heater and turned confidently to Lummus to meet their difficult design requirements.

First, the heater had to be large enough to service this giant Cat-Cracker; now one of the largest in operation.

Secondly, Humble wanted a high thermal efficiency, 86% as compared with the usual 75-80%. In the Lummus design, the heater utilizes Ljungstrom Air Preheater and integrated blower and duct system to attain high thermal efficiency. Operating performance has been consistently high. Humble's big fuel savings have more than made up for the slightly higher capital investment for air preheat equipment.

Finally, there was one other difficult design condition. The new heater would be required to operate for long periods without shutting down for maintenance or cleaning. The Lummus design included steam soot blowers which have kept both the bare tubes and studded tube in the convection section clean. The heater fires on heavy residual fuel oil having a very high solids content.

Lummus designs horizontal and vertical tube oil heaters to any size from 100,000 to 300,000,000 BTU/Hour for any process, anywhere in the world. Because Lummus offers *every* type of oil heater, you can be sure that we will recommend the *right* unit for your needs. Consult with Lummus on your next oil heater—large or small.

THE LUMMUS COMPANY, Oil Heater Division, 385 Madison Avenue, New York 17, New York, Houston, Washington, D. C., Montreal, London, Paris, The Hague, Madrid; Newark, N. J.

For more data on advertised products, use cards, last page.

Suddenly

you're in Outer Space

because you *"launched"* the MOST UNUSUAL Christmas gift-giving program for *customers, employees and friends* EVER SEEN!

★ ★ ★ ★

...and your customers, high in their praise of this SENSATIONAL idea, put you *"into orbit"* with their "THANK YOU'S" for your *unique and wonderful remembrance.* Their appreciation of course, opened the door to ADDITIONAL SALES! Even your employess and friends *showed their appreciation* in the many small ways ONLY YOU would understand.

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If you buy gifts *(between $7.50 and $100.00 each)*, you'll surely want to see this *unusually practical, sensationally simple* and *refreshingly different* way of saying "THANK YOU" to the people who are IMPORTANT TO YOU AND YOUR COMPANY.

WRITE FOR MORE INFORMATION ... MAIL THIS COUPON TODAY

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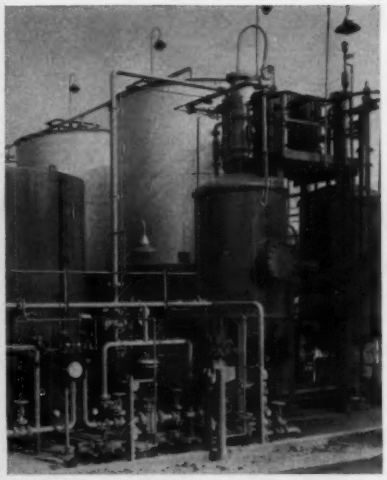
We use approx _____ Gifts in the $7.50 to $100.00 price range.

New Equipment . . .



storage time for settling and provides a haze-free product immediately prior to shipment.

The de-hazer removes water, solids, and residual caustic (or acid) from heating fuels. Utilizing the electric precipitation principle, the de-hazer operates automatically and at ambient temperatures. It has no moving parts, requires no steam, no filtering elements, and can handle a wide percentage range of water in fuel. Units can be designed to fit very small areas. Petreco Div., Petrolite Corp.

Circle E7 on green card, last page

Stack Coating Protests Against High Sulfur Fuels

A completely detailed brochure covering Stackfas, one of the world's first products designed exclusively to resist acid corrosion from high sulfur fuels, consists of charts showing the testing methods and results of Stackfas as compared to conventional coatings. Also included are scaled graphs of various types of chimney construction and the Stackfas method of protection, plus photographs showing methods of application.

In the past, many ideas and products have been evaluated to overcome the problem of corrosive flue gases in the temperature range of 180 to 350° F. One of the major failings of all past corrosion resistant materials was their inability to prevent concealed corrosion—the permeation of minute amounts of moisture-laden corrosive gases in brick linings or insulations.

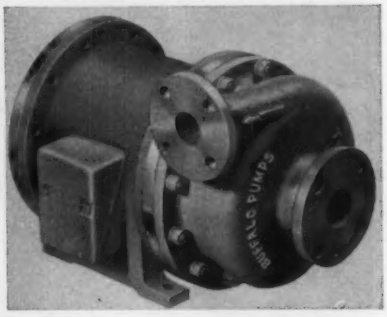
After two years of intensive research and field testing Stackfas has proved to be effective in eliminating the permeation of these acid gases and water vapor. Benjamin Foster Co.

Circle E8 on green card, last page

Centrifugal Pump Design Eliminates Mechanical Seal

A new line of centrifugal pumps, totally enclosed and hermetically sealed for use with inflammable or highly volatile liquids, features simplified design including a new, long-life, self-adjusting bearing. Mechanical seals and stuffing boxes are eliminated. Positive protection is provided against leakage of expensive or noxious liquids.

The new line at present will include 13 sizes, with discharges ranging from 1 to 5 inches. Standard units are designed for 120 psig and temperatures of 40 through 250° F. Special models are available for higher



pressures and temperatures. Complete details are available. Buffalo Pumps Div., Buffalo Forge Co.

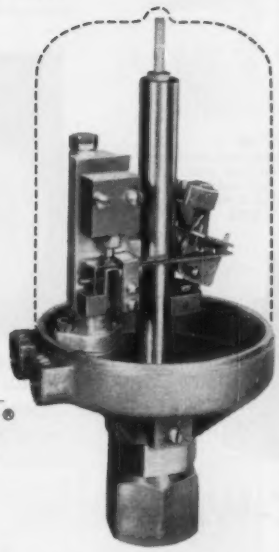
Circle E9 on green card, last page

Computer Checks on Condenser Performance

A condenser performance computer, that produces continuous records of condensate flow, condenser back pressure, cooling water inlet temperature and condenser back pressure deviation for proper evaluation of condenser operation, predicts the optimum pressure for the operating load (taking water temperature into consideration) and compares it with the actual back pressure measurement. The resultant deviation indication, which is independent of environmental conditions, instantaneously reveals a condenser fault.

The analog computer, in effect, plots a family of predicated condenser performance curves to determine expected condenser back pressure for the existing cooling water inlet tem-

NEW, non-bleed pneumatic liquid level controller



By

MAGNETROL®

model **J-2**

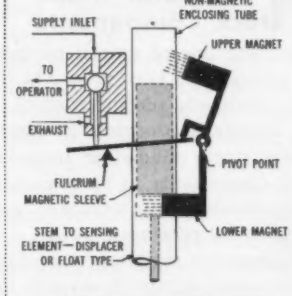
DEPENDABLE AS THE PULL OF A MAGNET

wherever you need

- **Ultra High Vibration and Corrosion Resistance—Chemical, Petrochemical and Petroleum**
- **Operation from Air, Wellhead or Other Gases**
- **Snap-Acting, Magnet-Controlled Actuation**
- **High-Speed Response for Liquid Metering and Rapid Cycling Processes**
- **Pressures to 40 psig Standard, to 100 psig on Application**

In the Magnetrol J-2 you get all the benefits of Magnetrol's unique magnetic operating principle applied to pneumatic ON-OFF, single-stage control of liquid levels . . . Dual magnets position a 3-way stainless steel valve—provide snap-action and positive holding even under heavy vibration. All metal operating parts are of stainless steel or aluminum for maximum corrosion resistance and are enclosed in a splash-proof housing. Suitable for all common temperatures and liquids. J-2 Switch Mechanism can be used with practically all Magnetrol units to provide reliable pneumatic control.

HOW IT WORKS



Magnetic sleeve, inside nonmagnetic enclosing tube, rises or falls with changing liquid levels. Attracting sleeve is **always** in field of upper or lower magnet. (Shown, low-level position.) Lower magnet is "pulled" in, supply inlet is open and air or gas flows to operator. On rising level, sleeve attracts upper magnet. In this position lever and fulcrum arrangement cuts off supply and allows air or gas trapped between operator and valve to exhaust to atmosphere. Reverse action can be provided by simple adjustment in the field.

Mail coupon today for full details—just attach to your letterhead.

MAGNETROL, Inc.

5312 Belmont Road, Downers Grove, Illinois

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Please send Catalog data and full information on Magnetrol J-2 pneumatic Liquid Level Controller.

Name_____

Pipeline Repairs are always quicker and safer with the

Completed Installation (Patent Applied For)

Completed Installation (When welding is specified) (Patent Applied For)

SMITH PLIDCO SPLIT-SLEEVE

Drastically reduces downtime losses
Permits welding while pumping

Nothing is quicker and simpler than repairing pipeline leaks with Smith Plidco Split-Sleeve. Assemble halves around pipe. Move assembly over leak and tighten side bolts.

Nothing could be safer. Exclusive steel girderings* prevent leaking oil or gas displacing gaskets. Weld if desired.

Stock, use Smith Plidco Split-Sleeves and save! Available in standard pipe sizes. Extra lengths, special dimensions on application.

*Patents pending

THE PIPE LINE DEVELOPMENT COMPANY
5700 DETROIT AVENUE - CLEVELAND 2, OHIO

Representatives Throughout the World

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Model 7300
Cast aluminum receptor; twin fountain heads direct automatically regulated streams into the eyes.

EMERGENCY EYE-WASH

Sensitive eye tissue can be destroyed in moments. Contamination from industrial caustics and chemicals requires instant first aid . . . and a HAWS Emergency Eye-Wash Fountain can mean the difference between temporary irritation and permanent injury! Write for your free HAWS catalog.

Since 1909 HAWS **EYE-WASH FOUNTAINS**

a product of HAWS DRINKING FAUCET COMPANY 1443 Fourth St., Berkeley 10, Calif.

Fuel oil accurately measured with Rotron Flowmeter by Clark Oil & Refining

The Rotron Whirl-Flo Flowmeter was installed at the Clark Chicago refinery in January 1960 to accurately measure fuel oil pumped from catalytic cracking to final product storage. Because of its inherent ability to handle liquids with suspended solids... even viscous fluids... the Rotron Flowmeter has proven efficient and economical from the day it was put into service.

Rotron Flowmeters are also being used effectively for such demanding uses as metering gas produced from oil and gas wells, gas and water used for oil well injections, and crude oil... as well as in-process control, accounting for final production, and product blending.

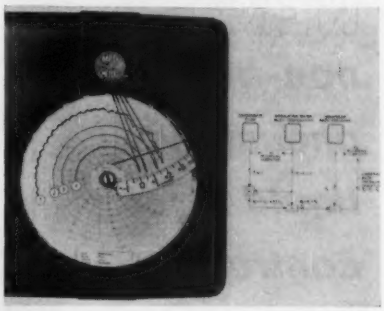
Rotron is your best buy for direct totalization... no electrical power required. Direct readout of flow rate at the meter or transmission to remote locations available... also automatic batch control plus ticket printing and recording.

Write for full details today.

ROTRON

ROTRON CONTROLS
Division of Rotron Mfg. Co., Inc.
65 Bearsville Road, Woodstock, N. Y.

New Equipment . . .



perature and condensate flow. Actual condenser pressure is measured and expected pressure is subtracted from actual pressure to give a deviation from expected performance. Bailey Meter Co.

Circle E10 on green card, last page

Ball Valve Brochure Has Selection and Cost Data

A new, four-page brochure describing the line of Econ-o-miser ball valves enables users to select the correct size, and combination of metals, seals, seats and pipe ends. In addition to illustrating the patented features, five types of pipe ends (flanged, screw end, socket weld, butt weld or welded-in-nipple) which can be used with the valves are shown. Thirteen photographs, four line drawings and five charts give complete information. A cost comparison between a standard ball valve, a standard gate valve and the Econ-o-miser is also given. Worcester Valve Co., Inc.

Circle E11 on green card, last page

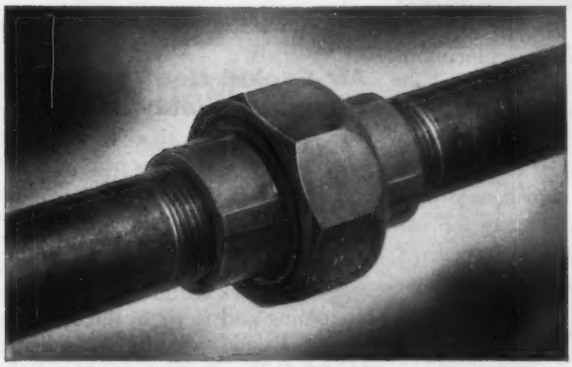
Analog Computer Made From Stock Components

A complete line of special purpose analog computers, known as PC-12, for fully automatic on-line control of various industrial processes is assembled from stock, solid-state modular designed components to meet particular requirements of chemical and other industrial processes.

The computers simultaneously and instantaneously accepted several inputs and compute several outputs based on complex mathematical relationships which apply to the particular process. The computers can be used in closed-loop control or as advisory devices for operator guidance.

The components were designed to

You can SEE the difference on the shelf



You can TELL the difference on the line

with Rockwood Unions

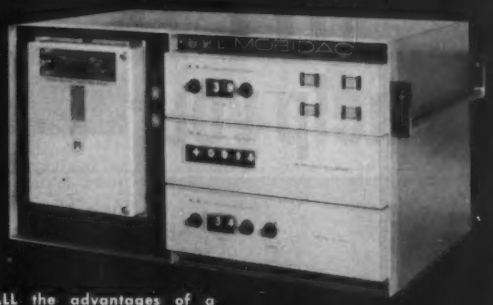
In every way — from packaging through performance — Rockwood Unions are superior to competing brands. *Yet they cost no more!*

The differences in Rockwood Unions tell their higher quality story:

Rockwood Unions are *boxed*, the contents clearly labelled and identified. *Only* Rockwood Unions have the hardness differential which assures fast, easy make-up, tight seal and freedom from galling. *Only* Rockwood offers *four* different seat types. *Only* tougher Rockwood Unions give you complete corrosion protection including "Rockwoodizing," the process that makes the threads and the entire surface of the union corrosion resistant. Longer service life under severe line conditions . . . greater resistance to vibration and shock . . . easier handling . . . Rockwood Unions give you *all* these advantages. Rockwood Unions are available in a wide range of sizes . . . all parts are interchangeable. Regardless of your needs, Rockwood Unions will do a better job for you. For complete facts write Rockwood Sprinkler Company, Union Department, **724** Harlow Street, Worcester 5, Mass. Distributors in all principal industrial areas. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E.W. Bliss Company.

ROCKWOOD
UNIONS

NOW PORTABILITY plus ACCURACY and up to 50% SAVINGS IN COST!



ALL the advantages of a conventional multi-rack data system in one PORTABLE package!

MOBIDAC
MOBILE DATA ACQUISITION SYSTEM

A Reliable and Economical Way to Record

- √ **STRAINS**
- √ **PRESSURES**
- √ **TEMPERATURES**
- √ **POSITION INFORMATION**

- **CONNECT YOUR TRANSDUCERS DIRECTLY** to MOBIDAC. No external d-c channel amplifiers required.
- **GUARANTEED DIRECT COMPATIBILITY** with all major computers. No tape translation required.

CONDENSED SPECIFICATIONS

Data Channels 48	**Output Format** Gapped or gapless for all major computers
Input Levels ± 4 millivolts to ± 4 volts	
Accuracy (full scale) 0.1%	**Test Identification** Run number is inserted on tape at beginning of test for identification
Sampling Programs Selectable by front panel switch	
Sampling Rate Up to 3000 sps	**Size** ..... 30" x 20" x 24"
Display Decimal display for individual channel data	**Weight** ..... 175 pounds
	Supply Voltage ..... 115 a-c volts

90 DAY DELIVERY

OPTIONS: Increased channel capacity . . . 100 or more, Higher Sampling Speeds, Quick-Look Display, Punched Tape and Card Outputs.

For Detailed Specifications and Prices, write Dept. PR

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SYSTEMS ENGINEERING LABORATORIES, INCORPORATED

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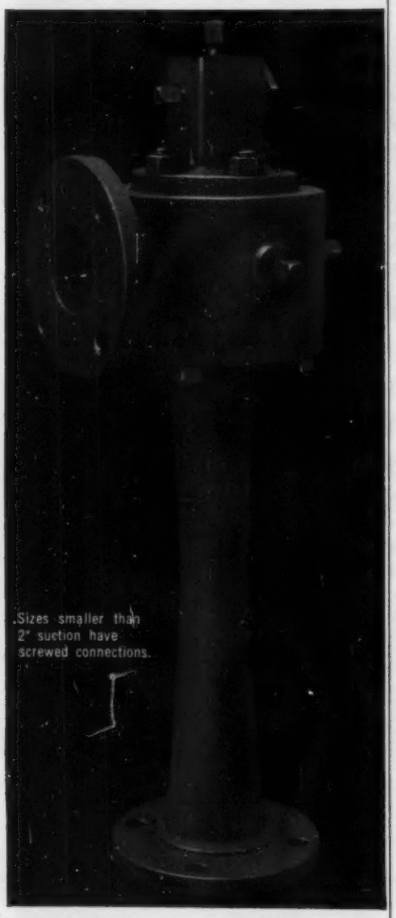
If you want an ejector in a hurry... ELLIOTT can help you

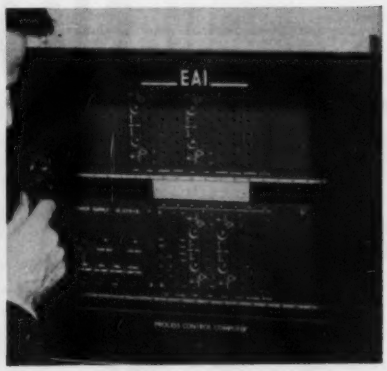


STANDARD Elliott ejectors in sizes up to 3-in. maximum suction are available for fast delivery. This simple, dependable, low cost, vacuum-producing device is well-designed and precision-made. Write for prices, giving application, pressures, temperatures, capacity required. G1-2

ELLIOTT COMPANY
GENERAL OFFICES: JEANNETTE, PA.
PLANTS: Jeannette and Ridgway, Pa.; Springfield, Ohio

TURBINES • GENERATORS • MOTORS • COMPRESSORS • TURBOCHARGERS • EJECTORS • STRAINERS • TUBE CLEANERS

New Equipment . . .



meet typical process environments of high humidity, corrosive atmosphere and wide temperature extremes. During assembly, the components are permanently programed to meet specific customer needs and housed in a special case with lock, ready for on-line installations. Basic components also will be sold to customers who desire to assemble their own computers. Electronic Associates, Inc.

Circle E12 on green card, last page

16-Page Booklet Covers Pump Fundamentals

"Pump Fundamentals," a 16-page booklet, gives the reader an elementary outline of the characteristics, operation and selection of reciprocating, rotary and centrifugal pumps. Being non-technical, it is applicable to those interested in a basic knowledge of pumps. Emphasis is placed on centrifugal pumps because of wide usage of this type. Definitions, basic formulas, examples and miscellaneous data frequently used in pump application are included. Goulds Pumps, Inc.

Circle E13 on green card, last page

Air-Cooled Heat Exchanger Eliminates Field Assembly

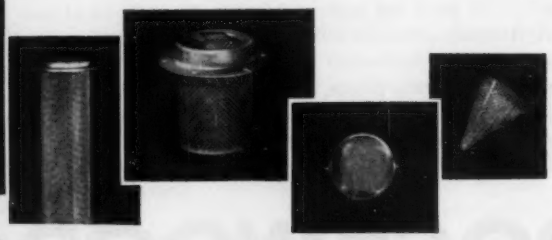
A standardized, air-cooled heat exchanger that eliminates field assembly is pre-erected and ready for hookup.

The new cooler's standard design cuts elapsed time between delivery and startup to a matter of hours. The only field work required is to connect the piping and to tie in the electrical system. In addition, the standardized nature of the cooler eliminates much

HOW COMPLEX ARE YOUR FILTERING AND STRAINING PROBLEMS?

Complexity in filtering and straining problems demands woven wire cloth. For this medium favors high, uninterrupted flow . . . is stable and will not creep . . . is versatile and can be fabricated to meet exacting requirements.

Cleveland Wire Cloth has the experience and facilities to solve your filtering and straining problems. We match your specifications in any metal or alloy . . . in any mesh count and mesh size. Will fabricate single and multi-screen strainers in any shape or size. Write for Bulletin describing woven wire screens for filtering and straining.



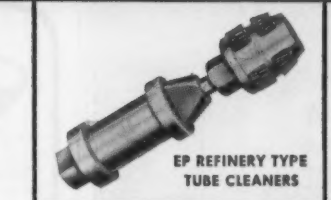
CLEVELAND WIRE CLOTH

THE CLEVELAND WIRE CLOTH and MANUFACTURING COMPANY
3571 E. 78th Street • Cleveland 5, Ohio • DI 1-1832

BETTER TOOLS FOR BETTER WORK

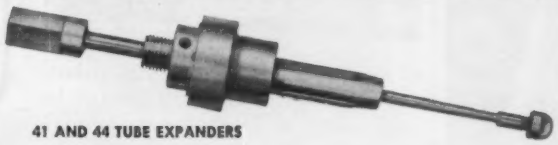
Wilsonize to economize— the buy-words in tube maintenance

Wilson has hundreds more to meet every tube maintenance need. Send for comprehensive catalog 77-88.

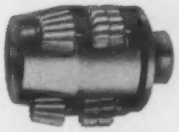


EP REFINERY TYPE TUBE CLEANERS

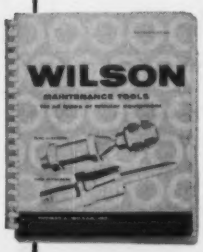
HEAVY-DUTY HEAT EXCHANGER CLEANER

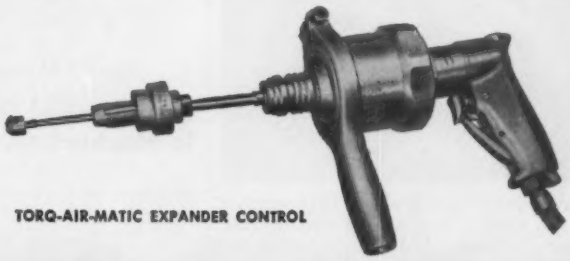


41 AND 44 TUBE EXPANDERS



R CUTTER HEADS



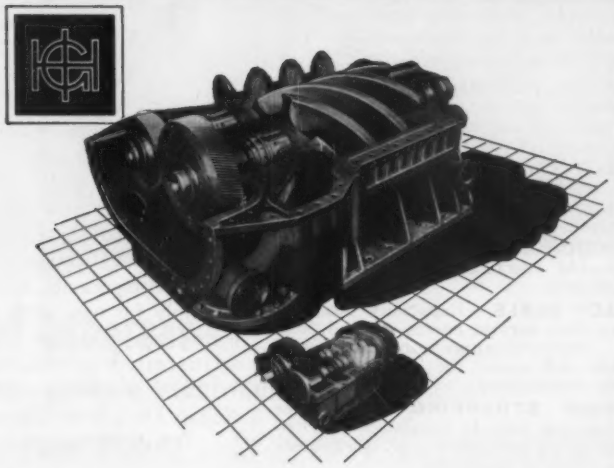


TORQ-AIR-MATIC EXPANDER CONTROL

TW-914

THOMAS C. WILSON, INC. 21-11 44TH AVE., LONG ISLAND CITY 1, NEW YORK
Representatives in principal cities • Cable address: "Tubeclean", New York

GHH SCREW COMPRESSOR



- Oil-Free Operation
- No Metal-to-Metal Contact of rotating elements
- Over 600 Units in Operation handling air, hydrocarbons, and many other gases
- Suction Volumes 350 to 15,000 cfm
- Compression Ratios up to 1:4.5 for single stage and 1:11 for two-stage units

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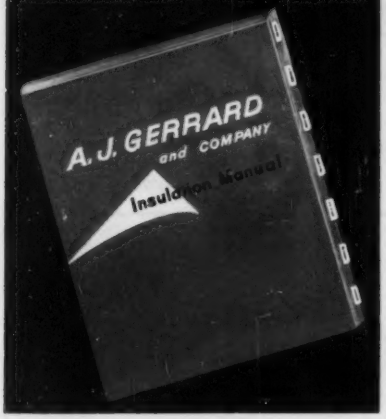
For more data on advertised products, use cards, last page.

There is ONE RIGHT STRAPPING for your INSULATION and CORROSION PROBLEMS



How do you know which is the right one? Consult the A. J. Gerrard Insulation Manual. It is available to qualified people who will write to us on their letterhead.

As a guide to specifying, it includes corrosion and technical data. It shows how other companies were able to properly insulate vessels, lines, vats, tanks, etc. And it covers the tools, materials and methods needed to strap insulation quickly, properly and economically.

EXPAND-R-STRAP — Expands and contracts with the vessel assuring even pressure against insulation at all times. Corrosion resistant.

ALLOY STRAPPING—Lets you select the right strapping for specific corrosive conditions; stainless, monel, galvanized, brass.

TENSIONING TOOLS—Easy to use—enable you to tension and cut strap in seconds.

ALLOY SEALS—Especially designed to combat varying corrosive conditions . . . stainless, aluminum, galvanized, brass and monel for all widths and sizes of strapping.

FINGER STRAPPING — Apply as strapping, impale insulation, secure with spring washers. For all thicknesses and types of insulation.

SPACERS & CLAMPS—Created for steam tracer lines.

WIRE, STAPLES & PINS—Available in all alloy grades to meet specific corrosive conditions.

Immediate delivery from conveniently located stocks.

To get a copy of the Insulating Manual, write on your letterhead to:

A. J. GERRARD & COMPANY

438 E. TOUHY AVE., DES PLAINES, ILL.

New Equipment . . .

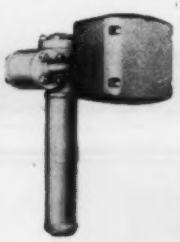
of the time spent in approving prints.

The M-Series units, designed to be used singly or in combination, have proven significantly economical when coupled in parallel to handle large cooling problems. Smithco Engineering, Inc.

Circle E14 on green card, last page

Liquid-Level Transmitter Is Mechanical, Electronic

A new, liquid-level transmitter that combines the accuracy of mechanical measuring and the efficiency of electronic signalling transmits dc signals proportional to level variations and is readily adaptable to all systems using electronic indicators, recorders or controllers.



Feature of the new instrument is the LVTD displacement transducer coupled with an amplifier with solid-state circuity. High feedback maintains extreme accuracy and stability even in changing ambient conditions. The amplifier contains only highest quality components, and is of plug-in assembly for ease of maintenance. A wide range of signals is available, and adjustment is simple. Accuracy Within 1 percent is reported. Mason-Neilan Div., Worthington Corp.

Circle E15 on green card, last page

Refractory Improved for Catalyst Carrying Lines

A new, high-strength castable refractory has been developed for pneumatic gun placement with low rebound and minimum dusting. Placed by wet or dry-gun methods, the new Kaogun-HS castable produces a high-strength monolithic body with outstanding abrasion resistance and excellent resistance to thermal shock.

The new gunning castable has a

B-I-F POSITIVE CONTROL OF MATERIALS FLOW

Want to get into the #4 and #5 oil market without costly, additional tankage? Want to free any existing #4 and #5 oil tankage you have for other service? Stock only #2 and #6 . . . deliver these and any intermediate grade simultaneously, directly to your tank trucks with B-I-F's compact TC Blender.

Free Facts

Stock TWO, sell THREE . . . at savings up to ½¢ per gallon. For greatest flexibility in end-product specifications, maximum production from existing real estate and personnel, lower taxes, and reduced inventory . . . request free FACTS today!

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A DIVISION OF THE NEW YORK AIR BRAKE COMPANY

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More than
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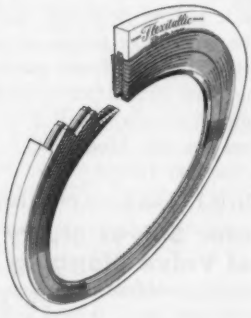
represented in the latest "Construction Boxscore of the Hydrocarbon Processing Industry" published in Petroleum Refiner use Flexitallic Spiral-Wound Gaskets. This confidence of companies, engineering firms and contractors in Flexitallic Gaskets is based on their superior performance.
It is sincerely appreciated.



Flexitallic®
SPIRAL-WOUND GASKETS

Lifeline of progress

...where gaskets must not fail

In the processing of hydrocarbons, and in the steam lines of today's refinery, where the price of gasket failure is high, engineers rely on Flexitallic Gaskets.

Flexitallic's engineered spiral-wound construction gives yield characteristics to the gasket that provide extra safety under critical sealing conditions.

Every Flexitallic Gasket is designed for a specific application. Flange geometry, bolt load, pressure, temperature, corrosion, vibration, joint stress — all are considered. Flexitallic engineers then select the type of metal and filler to provide the proper seal. In the Flexitallic Gasket shown, the Flexite Finish protects the gauge ring in corrosive atmospheres.

For temperatures from extreme sub-zero to maximum temperatures compatible with available metals. Pressures ranging to 15,000 lbs. p.s.i., temperatures to 2500°F. do not impose impossible limitations.

Give us the facts about your most serious sealing requirements — in chemical processing, petroleum, power, marine, aircraft and missiles, diesel, or any other field. There's a Flexitallic Gasket to meet your needs — or Flexitallic will design one.

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Stocking Distributors for Standard
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VALVE OPERATORS
Adaptable to NEW and EXISTING VALVES
THOUSANDS of operators in service throughout the world, typical examples of SADI power transmission equipment quality
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recommended use temperature of 2,500° F. Gunning applications for which the castable is suitable include linings for stacks, boiler furnaces, dust collectors and settling chambers, catalyst carrying lines in refining and petrochemical plants, by-pass stacks in CO boilers and seal tanks.

A high-alumina cement provides an exceptionally strong hydraulic bond for Kaogun-HS which has a highly calcined, carefully graded base. Two gunning contractors on field test jobs involving three carloads of the new Kaogun-HS reported low rebound loss. The new castable has demonstrated excellent strength and dimensional stability throughout its use temperature range. Resistance to abrasion is exceptionally high. The Babcock & Wilcox Co.

Circle E16 on green card, last page

Cleaning Bulletin Tells How to Do It Yourself

"Do-It-Yourself Cleaning of Towers and Exchangers" is the title of a new service bulletin published to acquaint refineries with economical methods of using their own personnel and equipment to clean towers, exchangers and other processing equipment.

With the aid of a detailed diagram, the bulletin outlines procedures which make maximum use of a refinery's existing lines, tanks, product and process pumps in establishing an economical "do-it-yourself" cleaning setup.

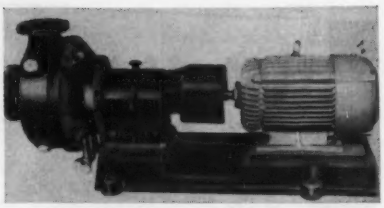
The bulletin discusses various factors which must be considered, such as refinery charge stock, types of metal, extent of soil deposits, local water conditions, etc. Oakite Products, Inc.

Circle E17 on green card, last page

Steam-Jacketed Acid Pump Handles Freezing Fluids

A new, completely steam-jacketed acid pump will handle any solution which freezes above ambient temperatures, such as ammonium nitrate, liquid sulfur, asphalt, etc.

Multiple steam-line connections are provided on the case, case plate and stationary seal ring housing. In use, any two connections on each jacketed part are connected to the incoming and return steam lines.

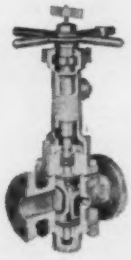


Steam connections are tapped for ¾-inch pipe. A. R. Wilfley and Sons, Inc.

Circle E18 on green card, last page

Non-Lubricated Plug Valve Insures Bubble-Tight Seal

The General Twin Seal Model "C" is an improved, non-lubricated, plug-type valve that provides a bubble-tight seal at upstream and downstream ports with a body bleed for positive checking of the seal. A patented plug assembly with two replaceable seating segments avoids abrasive contact of the seating surfaces.



When the plug moves downward, these seating segments are wedged outward to effect a double block. When the plug moves up, the segments retract and disengage from the body seats before the plug is rotated. This perpendicular seating action of the segments has a two-fold advantage: it eliminates galling or scoring of the seats, and it permits the use of soft, resilient seals. These seals, which are compressed against the precision-ground body, form a more effective bubble-tight shut-off than hard, non-resilient seals.

Improvements over previous Twin Seal models include an enclosed packing gland, roller bearings that decrease the amount of torque necessary to actuate valve, and fewer parts. Engineering and manufacturing improvements have also resulted in price reductions on the Model "C." General Valve Co., Inc.

Circle E19 on green card, last page

Oscillator Solves Slurry Control Valve Clogging

A clogging problem in a slurry control valve has been solved with an all-pneumatic timer, the Servo-Gauge oscillator, in the Houston plant of Shell Chemical Co. Opening the valve after partial closing about twice per minute produces flow impulses

Babbitt *Adjustable* **SPROCKET RIM**
with Chain Guide
CHANGES THAT DANGER ZONE TO A SAFETY ZONE

. . . cuts costs when you SIMPLIFY PIPE LAYOUT

When you modernize to make money, go all the way. Cut piping costs to minimum with planned simplification. Give your staff a free hand to effect economics—at the same time, convert Danger Zones to Safety Zones. Equip every overhead valve wheel in your plant with Babbitt Adjustable Sprocket Rims with Chain Guides.

- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. Just phone your mill supply salesman, or contact us direct.

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BLEND GASOLINE ON THE SPOT!

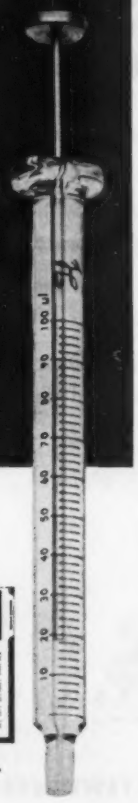
CATALOG DESCRIBES NEW BLENDING SYSTEMS

New Blackmer Vari-Flo Systems blend a regular with a premium grade gasoline right in the pipeline to deliver the desired octane directly into tank car or transport. Cuts down on tankage, piping and inventory. Virtually eliminates vapor loss and contamination. Blackmer Vari-Flo Systems have been used with remarkable success in blending gasolines and many other liquids. Their simplicity—the result of a unique mechanical principle—opens up new applications for which other types of equipment may be too costly or complicated. Read about Blackmer Blending Systems in Refinery Catalog. **Or write us for Bulletin 650G.**

"liquid materials handling"® equipment
BLACKMER / *blending systems*
BLACKMER PUMP COMPANY, GRAND RAPIDS 9, MICHIGAN

Hamilton Microliter Syringes

Precision Syringes from 1 ul to 500 ul



Here's the syringe that meets the demand of precision analysis by offering accuracy, greater sensitivity, speed and minute—yet accurate discharge. They're quality built too, with individually fitted stainless steel plungers in precision bore NC glass to assure leak proof performance. By meeting critical demands, they have become the standard in gas chromatography, chemistry, biology and medicine.

FREE LITERATURE on Hamilton Microliter Syringes, just clip this ad to your letterhead and mail.

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P.O. Box 307-X, Whittier, California

Leashes For Glassware

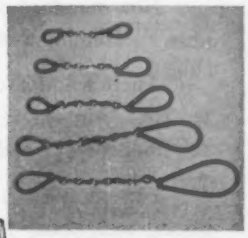
NON-RUST—STAINLESS STEEL SPRING

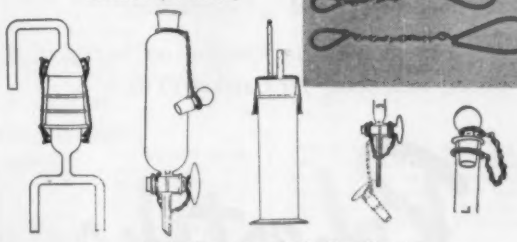
Available in five sizes: Extra Small, Small, Medium, Large and Extra Large. In addition we furnish Assorted Sizes in envelopes of one dozen, consisting of two Extra Small; two Small; four Medium; three Large and one Extra Large.

How To Use Leashes: Simply slip the small spring loop over the top of stopper or stopcock plug while the large loop is slipped over the stopcock shell or the neck of bottle, flask, cylinder, etc.

To Save Glassware: Apply Leashes to all newly received glassware shipments. Use, clean, and drain-dry your glassware without removing Leashes. This keeps your expensive glassware parts together.

Envelopes of one dozen
Leashes, Extra Small, DS 120ES
" Small, DS 120S
" Medium, DS 120M
" Large, DS 120L
" Extra Large, DS 120EL
" Assorted (as above)





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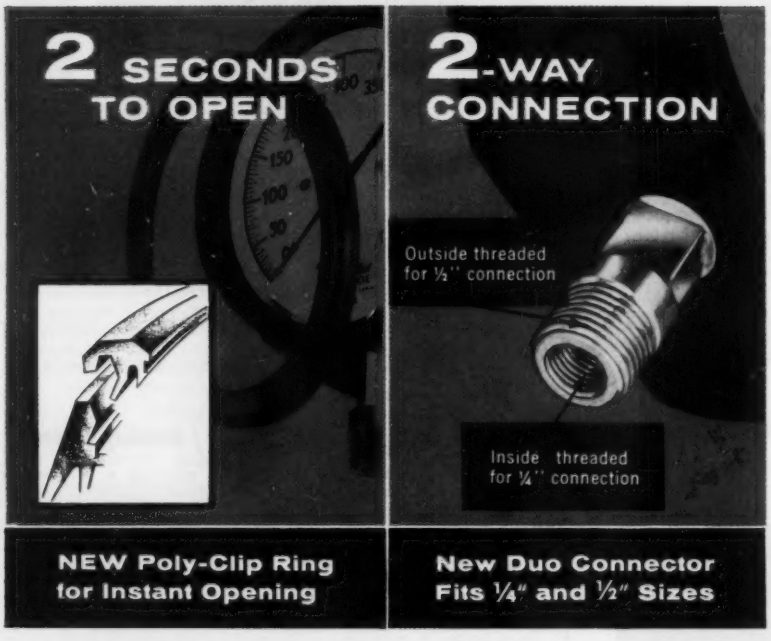
NEW ACRAGAGE® CONVENIENCE


2 SECONDS TO OPEN
2-WAY CONNECTION
Outside threaded for ½" connection
Inside threaded for ¼" connection
NEW Poly-Clip Ring for Instant Opening
New Duo Connector Fits ¼" and ½" Sizes

No more retainer-ring corrosion . . . no more glass breakage when prying out stubborn rings!

This new polypropylene ring snaps in and out instantly without special tools . . . and gives you a positive, weather-tight closure.

Now standard on all phenolic Acragage cases, it is also available on aluminum or iron cases for special applications.

There's added convenience, too, in our exclusive new Quarter/Half Connector. The single fitting is threaded inside and out for standard ¼" and ½" connections.

For complete information on Acragage styles, ranges and prices, write today for Catalog TT-G.

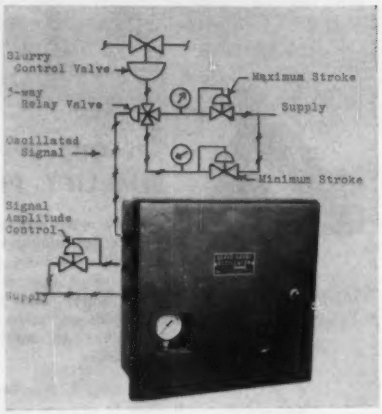
Robertshaw

Robertshaw-Fulton Controls Company

MR. CONTROLS

FULTON SYLPHON DIVISION, KNOXVILLE 1, TENNESSEE

New Equipment . . .



that free the valve of accumulated material. Associated Control Equip.

Circle E20 on green card, last page

12-Page Bulletin Gives Turbine Flowmeter Data

A new technical bulletin describes a broad line of turbine flowmeters used to measure flow rate and total flow, and for automatic process control in batching and blending systems of liquids, gases and cryogenics.

Complete information on ranges, accuracies, frequency outputs, accessory equipment, calibration procedures, together with detailed photographs and charts is included. Cox Instrument Division, George L. Nankervis Co.

Circle E21 on green card, last page

Ball Valve Brochure Has Pressure-Temp Ratings

A new high-pressure ball valve brochure describes available sizes, materials, pressure-temperature ratings and various applications of this line of valves.

Also included are high-pressure "fire-safe" ball valves, high-pressure Stelock ball seals, fire-safe stem packing and body gaskets, and a resume of the physical properties of Nylon and Delrin. Pacific Valves, Inc.

Circle E22 on green card, last page

Technical Data on Rotary Pumps and Filters Given

New literature gives technical data and application information on a line of positive displacement rotary pumps and on an extensive line of pump filters in sizes from ½ up to 30 inches. Plenty & Son, Ltd.

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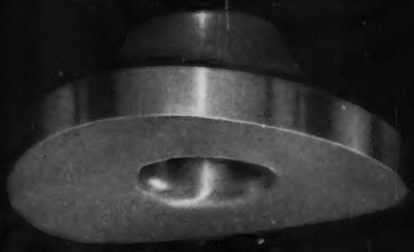
ANTICIPATION



Insert-Type Connections for
Aircraft Carrier Catapult Steam Accumulators

High strength steel connections — contour forged and machined to exacting measurements — built to last under extreme pressures — these are the requirements of America's modern aircraft carriers. In anticipation of the ever-changing needs and new applications of military and industry, Lenape constantly searches for improved pressure vessel connection designs of all types.

Write today for Catalog describing the complete Lenape Line.

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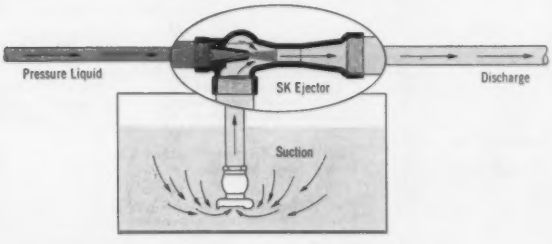
PUMP AND MIX SIMULTANEOUSLY

SK Liquid Jet Ejectors utilize the kinetic energy of a liquid under pressure to entrain, mix, and pump liquids or handle slurries and granular solids. Uses vary from pumping out a sump to mixing chemicals in proper proportions.

Some user benefits: (1) *economy*—a 2-inch, bronze unit costs only $51.00; (2) *maintenance-free service*—simple construction and lack of moving parts makes supervision unnecessary; (3) *availability*—stocked in popular sizes in Pennsylvania, Texas, California; (4) *adaptability*—made and stocked in cast iron, bronze, stainless steel, asbestos-filled resin, PYREX brand tubing, and PVC.



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Schutte and Koerting COMPANY

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INSTALL AND FORGET!

Meet Sarco's steam trap... application-engineered to outside tracer lines

Continuous processing should *not* have to be concerned with downtime caused by steam trap trouble in tracer lines. In practically all such situations, Sarco's Thermo-Dynamic Steam Trap, Type TD-50, can solve all these problems: widely varying pressures . . . remote and inaccessible locations for maintenance . . . water hammer, and freezing.

Simplest, most compact steam trap made, the TD-50 has only one moving part. It operates perfectly without adjustment through its full pressure range of 10-600 psi. It rids lines of condensate and air as rapidly as they're formed. Write for Bulletin 257.

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Adjustable for signalling pressure and differential pressure from 0.25" wc to 200 psi (or psid) in systems to 5000 psi and −65° to +275°F; leak-proof. Units sound alarm, light bulb, turn motor on or off, operate valves—remotely or in place. **$40 to $75**

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Adjustable and non-adjustable. Actuation 0.01 to 100 psi (or psid). For same pressure/temperature as switches. Red button pops to give visual indication of overpressure. **$22 to $85**

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For system pressures to 3000 psi; indication from 0 to 60 psi differential; leak-proof—no moving seals; high-visibility scale. **$92**

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CHEM SHOW

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* The asterick preceding name of advertiser indicates that detailed data on products and services of the firm will be found in The 1961 Refinery Catalog.

A

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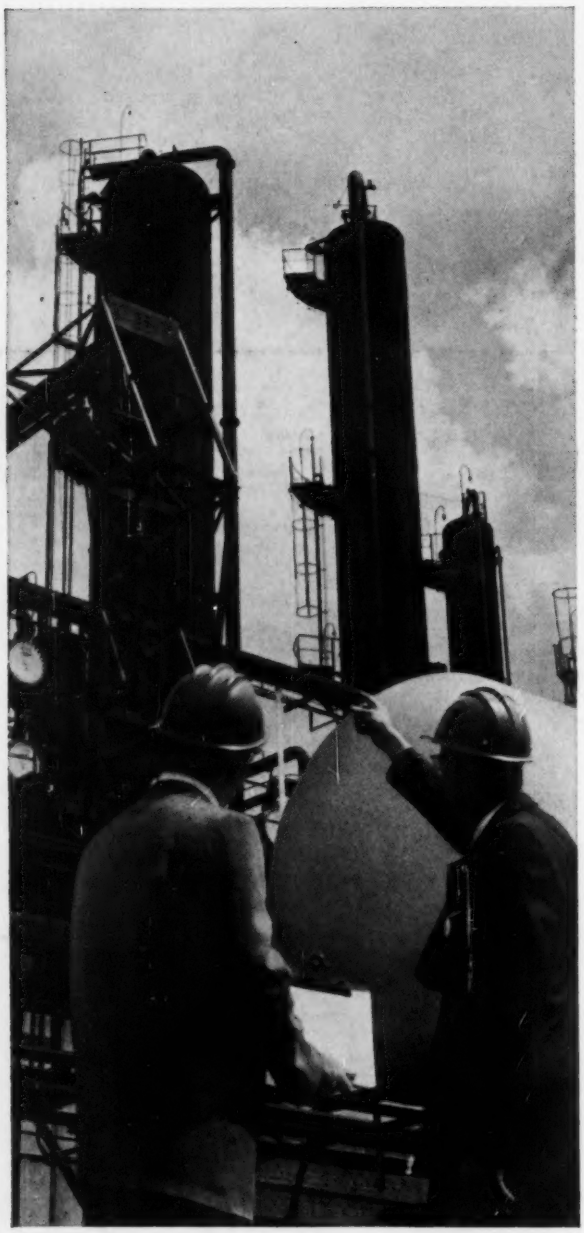

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